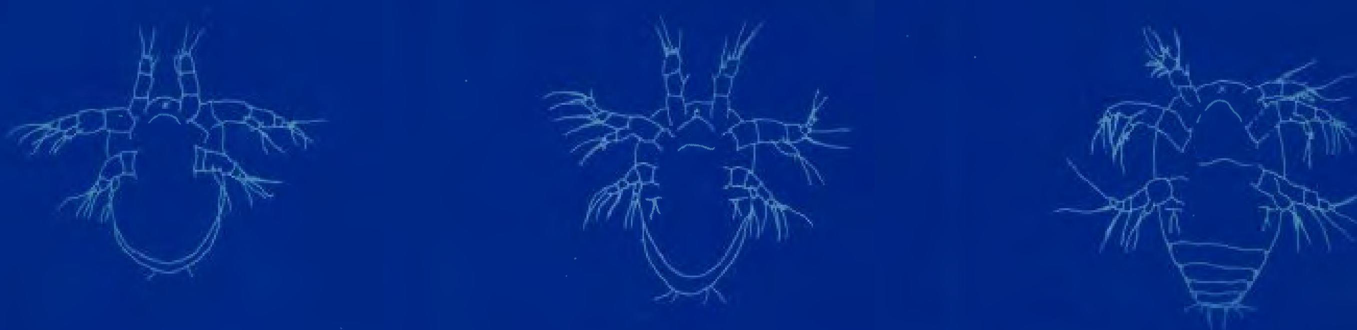
Fish Quarantine and Fish Diseases in South and Southeast Asia: 1986 Update



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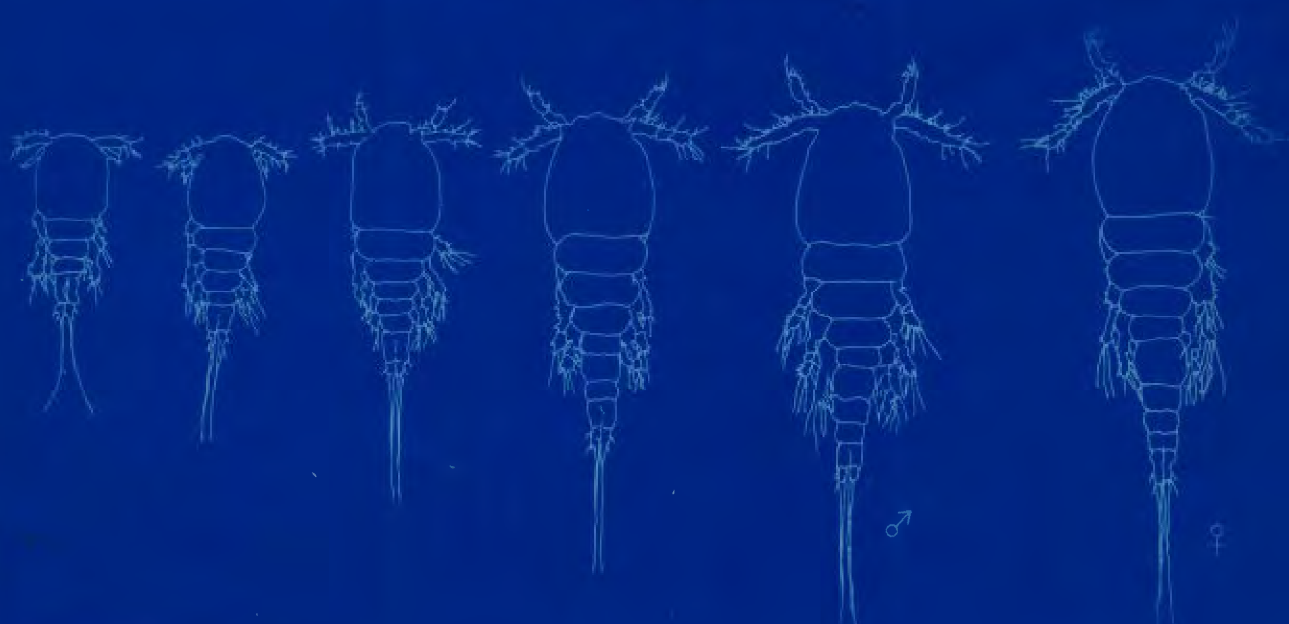

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Fish Quarantine and Fish Diseases in South and Southeast Asia: 1986 Update

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Cover design: Developmental stages of *Lernaea cyprinacea* and *L. polymorpha*. Courtesy of M. Shariff and C. Sommerville.

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FOREWORD

This report documents the proceedings of a one day workshop on two topics of growing importance to South and Southeast Asian government agencies, university researchers, and aquaculturists: current fish disease problems in the region and the status of programs for fish quarantine and certification. These topics were the subjects of previous IDRC-sponsored meetings held in 1978 and 1982 in Cisarua and Jakarta, Indonesia, respectively. Since 1982, major disease outbreaks have occurred in Thailand, Burma, Laos P.D.R., Indonesia, Malaysia and the Philippines, with accompanying severe financial losses to the fish growers and to small-scale rural fishermen. Outbreaks of "epizootic ulcerative syndrome," a disease of still uncertain etiology despite considerable research effort, have created increased awareness among high level government administrators of the importance of fish disease research and have resulted in the implementation or planning of quarantine and/or certification programs in several countries to prevent the introduction of exotic fish pathogens.

Many fish health workers were in attendance at the First Asian Fisheries Forum, held in Manila during May 26-31, 1986. The Fish Health Network took this opportunity to organize a workshop to provide these scientists a chance to update themselves on recent developments and advances made in the two session topics during the past four years.

Following the workshop, a survey of fish health workers in the region was made, the results of which strongly favored the formation of a society. An approach was made to the Asian Fisheries Society, which agreed to the establishment of a "Fish Health Study Group" of the Society. As the Society grows, this Group is expected to become a formal "Fish Health Section" of the Society.

The Asian Fisheries Society is pleased to assist the Fish Health Study Group in its efforts to promote research on fish disease matters and to create an awareness of their importance in Asia. Publication of this book by the Society in association with IDRC is a first step in that direction.

On behalf of IDRC, we would like to extend sincere thanks to the staff of the Bureau of Fisheries and Aquatic Resources, Fish Health (Philippines) Project for their kind assistance in making local arrangements for this meeting; to Mr. V. Soesanto, Chief Technical Advisor, ASEAN/UNDP/FAO Regional Small-Scale Coastal Fisheries Development Project, for providing facilities for wordprocessing; and to Ms. Julie Yap for her careful typing of the manuscript.

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CONTENTS

Session I Summary

RECENT FISH DISEASE PROBLEMS IN SOUTH AND SOUTHEAST ASIA AND THEIR ECONOMIC IMPACTS

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It is apparent from the catch records of various countries in South and Southeast Asia that the amount of fish caught from the natural environment is decreasing yearly. To overcome this shortage, the governments of many countries within the region have intensified the culture of fishes in ponds or floating cages.

This intensive fish farming inevitably encounters disease problems which constitute a major threat to increased production. The control of diseases is a crucial factor in the success of intensive fish culture. This problem has been well recognised for many years by local culturists, as the economic losses due to diseases can be substantial.

The major diseases associated with fish culture in this region may be divided into two main groups, namely protozoan diseases and microbial diseases. The protozoan diseases affect mainly fry and juveniles whereas microbial diseases affect both young and adult fishes.

Protozoan diseases

The most prevalent protozoan diseases of fish are caused by the holotrichous ciliates *Ichthyophthirius* in freshwater and *Cryptocaryon* in marine environments, the trichodinids in both environments, and the myxosporeans (primarily *Myxobolus*) in freshwater culture systems. These protozoans are most detrimental and cause great losses of cultured fishes, be it freshwater or marine species. Many protozoans are cosmopolitan and their spread is made easier by the transportation of live fish across national borders without quarantine.

More research has been carried out on the genera *Ichthyophthirius* and *Myxobolus*, particularly in China and, to some extent, in Indonesia. By far the most prevalent ciliate is *Ichthyophthirius multifiliis* Fouquet, 1876. The optimal temperature for its reproduction ranges between 20-25°C. Of great concern is the appearance in China of a heat-resistant strain which reproduces at temperatures above 30°C. This particular species has been reported throughout Asia and has been introduced to many parts of the world.

The myxosporean parasites *Myxobolus artus* Akhmerov, 1960; *M. carassii* Klokaceva, 1914; and *M. drjagini* Akhmerov, 1954 are very pathogenic to fry in China, as is *M. koi* Kudo, 1920 in Indonesia. No chemicals are ideal for the control of these protozoans because of the resistance of their spores. As a result, spores tend to accumulate at the bottom of ponds. They have the ability to survive in vacant ponds and still retain their infectivity after three years.

Studies in China and Indonesia have shown that many myxosporeans are host-species specific and that the severity of infection is often a function of host age. Fish that survive initial infections may show a self-cure phenomenon. It has been shown in China that alternating the use of nursery and stocking ponds is effective in reducing infections. This prophylatic measure should be tested and adapted for use in other countries.

In the marine environment, the ciliates *Cryptocaryon* and *Trichodina* appear to be pathogenic to juvenile seabass (*Lates calcarifer* (Bloch)) that are imported for culture in Malaysia and Singapore. Affected fishes suffer loss of appetite, become lethargic, lose scales, and have long white fecal casts. It appears that there are no control measures or treatments for effective removal of these protozoans in cage culture situations. Prophylatic measures should be developed.

Microbial diseases

Microbial diseases also appear to be a major problem in freshwater and marine fish culture in this region. The majority of bacterial diseases seem to be caused by the genera *Pseudomonas, Aeromonas,* and *Flexibacter* for freshwater fishes and the genus *Vibrio* for marine fishes. The common species associated with these genera are *Pseudomonas fluorescens, Aeromonas hydrophila, Flexibacter columnaris, Vibrio parahaemolyticus,* and *V. alginolyticus*. Viral diseases may also be of major significance, but have not been studied to any extent in the region.

Microbial diseases are typically infectious and can easily spread to other fishes within the same system. In general, the symptoms associated with these diseases seem to be ulceration, necrosis, and hemorrhage. Greater research efforts on microbial diseases have been carried out by researchers in China, especially on diseases affecting fishes of the family Cyprinidae, particularly grass carp *(Ctenopharygodon idella* Cuvier and Valenciennes). The etiological agent for the hemorrhage disease of grass carp has been identified as a reovirus.

Research into the vaccination of fish against microbial diseases in China has shown encouraging results. About 80% of the fish vaccinated by intraperitoneal injection was found to be immune to the main microbial diseases. This immunity can last for about 14 months. However, vaccination by intraperitoneal injection is very tedious and time consuming and other easier methods should be developed.

Outbreaks of many microbial diseases appear to occur in single fish species in polyculture systems. Recently, outbreaks of epizootic ulcerative syndrome occurred in the Indo-Pacific region that affected many species at the same time in both natural waters and in culture systems. This syndrome appears to be best documented in Thailand, which experienced its first severe outbreak in late 1981. Since then, outbreaks have recurred every year at almost the same period, between September and March, particularly after heavy rainfalls.

The symptoms of epizootic ulcerative syndrome appear very similar for all species affected. Fish tend to congregate at the water surface and display abnormal swimming behaviour. Large and deep ulcers were commonly found on the body, and in some instances, the caudal peduncle was completely eroded away. The head may also be eroded, the extent depending on the species, the erosion including the maxilla and mandible, and the skull, which may expose the optic nerves and even the brain.

The etiological agent (or agents) of this syndrome has not been ascertained as yet. Bacteria, mainly *Aeromonas hydrophila*, have been claimed to be the most important pathogens involved in the various outbreaks. Parasites, fungi, and viruses have also been found in diseased fish. Although several potentially pathogenic organisms have been identified, none of them can be designated beyond doubt as the primary cause.

In the marine environment, vibriosis appears to be prevalent and may reach epizootic proportions. The etiological agents for vibriosis are various species of *Vibrio*, particularly *V. parahaemolyticus*, and *V. alginolyticus*. Recent research in Malaysia on vaccination through immersion shows promise. Under laboratory conditions, vaccinated fish appear to be immune to vibriosis. However, field trials should be conducted to determine its effectiveness in the natural environment, where various interacting factors come into play.

Although protozoan and microbial diseases were highlighted in this summary, one must not forget that other pathogens, such as metazoan parasites and fungi, can play an important role in disease outbreaks. They should also be studied to determine how they may contribute to disease.

Economic impacts of disease

It appears from the various national reports that it is quite difficult to quantify the economic impact of fish diseases on the aquaculture industry. This difficulty appears to be due to a lack of detailed documentation in cases of epizootics of fish diseases.

The few well documented cases of fish disease outbreaks indicate that losses are considerable. In Thailand, the economic losses caused by epizootic ulcerative syndrome during 1982-83 were estimated to be about US$8.6 million. As a result of this disease, market demand for both freshwater and marine food fishes decreased drastically, as consumers avoided eating all fish for fear of disease transmission. In Malaysia, the survival rate of marine fishes cultured in floating cages can be determined. It was calculated that the annual loss due to diseases or associated problems is about US$1.2 million. In Sri Lanka, it is estimated that losses due to diseases or other problems in government hatcheries is about US$68,000 per year.

From these examples, it can be seen that the economic impact of disease on the fishery industries, especially aquaculture, can be tremendous and in some instances could be sufficient to cause the collapse of the local fish culture industry.

CURRENT FISH HEALTH PROBLEMS IN CHINA[1]

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Research on freshwater fish diseases in China started in the early 1950's when fish farmers pointed out that the control of diseases was crucial to freshwater fish culture. Hosts of different ages are susceptible to different diseases, parasitic diseases are mostly encountered in juveniles while microbial diseases are generally found in fishes beyond one year.

Protozoan diseases

Most protozoan parasites occur in fish fry. Ciliated protozoa infect the body surface and gills of their hosts. These include *Chilodonella; Apiosoma;* and several common trichodinids, *Trichodina nobilis* Chen, 1953; *T. orientalis* Chen and Hsieh, 1964; and *Trichodinella myakkae* (Mueller, 1937). Multiplication of the parasites on the host leads to heavy infections which soon weakens young fry and can result in heavy mortality. The most prevalent ciliate is *Ichthyophthirus multifiliis* Fouquet, 1876, which multiplies at an optimal temperature of between 20-25°C. In recent years a heat-resistant strain appears in the summer at temperatures above 30°C. No chemical treatment is considered ideal. This ciliate becomes an immense threat to laboratory work when fish are kept at high density in small aquaria.

In the 1960's, myxosporean protozoa became the most devastating of all parasites. *Myxobolus artus* Akhmerov, 1960 is a histozoic species parasitic in the anterior intestine of the fry of grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes). Mortalities may reach as high as 90% on the eleventh day after fry are transferred from the hatchery to nursery ponds. Numerous cysts occur in the intestinal tissue of the fish. Because of the resistance of the spores to most chemicals, innumerable spores accumulate on the bottom of the pond and thus the disease becomes aggravated and detrimental. In an experiment conducted by the author in Nanhai, a pond was left vacant for three years, but the spores were still infectious when fry were transferred to the pond. Nevertheless, despite its strong resistance to unfavorable conditions, this species has some weaknesses, infections being a species-specific function of the age of the host. Fish surviving the initial infection, on reaching 60 mm in length, manifest a self-cure reaction by developing connective tissue around the cysts. Gradually the spores within the cysts become dark and eventually perish. No infection occurs in fish older than one year. Based on this observation, the author suggested alternating the use of the nursery and stocking ponds as a prophylatic measure. Field tests proved satisactory.

Myxobolus carassii Klokaceva, 1914 infects the kidney and muscles of wild goldfish, *Carassius auratus* L., the symptom being the appearance of a dorsal

[1]Read by J.R. Arthur.

hump anterior to the dorsal fin. The seriousness of this disease resulted in the abandonment of goldfish culture in Jiangsu and Zhejiang Provinces. *Myxobolus drjagini* (Akhmerov, 1954), the causative agent of twist disease, while a trophozoite, infects the central nervous system, sense organs, and cerebral fluid of silver carp (*Hypophthalmichthys molitrix* (Valenciennes)), causing heavy mortality of this species in Hangzhou (Wu 1975).

The unicellular algae *Prymnesium parvum* Cartor occurs in great numbers in brackish water ponds along the northern seacoast, as well as in inland alkaline-salty marshes. *Prymnesium* toxin, the secretion of this tiny flagellate, kills almost every species of fish in these water bodies. This harmful phytoplankton can be controlled by the application of nitrogenous fertilizers to increase populations of other plankters so as to supress the population of *Prymnesium* (Wang 1985).

Metazoan parasite problems

Large populations of the monogenean *Dactylogyrus* can usually be found on the gills of fingerling bighead carp, *Aristichthys nobilis* (Richardson), in the wintering ponds. These parasites do not constitute a serious threat, being easily controlled.

Among the digenetic trematodes, members of the genera *Diplostomum, Clinostomum,* and *Sanguinicola* are sometimes epizootic under the conditions of intensive pond-culture. The geographical distribution of *Diplostomum* is related to the migration of the definitive hosts, gulls and terns. Worm cataract, caused by the metacercariae of this fluke, is confined to North China and along the Yangtze River. Similarly, the geographical distribution of *Clinostomum* closely parallels that of its definitive hosts, fish-eating egrets and herons. This fluke occurs only sporadically in the south, where it may become a problem in aquaculture ponds on some occasions. *Diplostomum, Clinostomum,* and *Sanguinicola* all share a common first intermediate host, the snail *Radix swinhoei.* Thus, these flukes can be efficiently controlled by eradicating this snail.

Bothriocephalus acheilognathi Yamaguti, 1934, parasitic in great numbers in the anterior intestine of young grass carp, was found as a localized disease along the Pearl River in the early 1950's. However, the disease has spread widely since then to many parts of the world (See Fernando and Furtado 1963; Könting 1975; Bauer and Hoffman 1976; Andrew, *et al.* 1981). It can be controlled either by killing the eggs and the intermediate host (cyclopoid copepods) after the annual removal of diseased fishes in the spring with a 1/2000 concentration of lime or 50 ppm bleaching powder or simply by keeping the pond vacant for 50 days after the annual clearance (Liao and Shih 1956).

Metacestodes of *Ligula* and *Digramma* are widespread and dangerous parasites of cyprinids in lakes and reservoirs. Their geographical distributions indicate three distinct major zones: the Qinghai-Tibet Plateau is dominated by *Ligula*; the rest of China, with the exception of a crescent-shaped area bordering part of the southern coast down the Hainan Island of Guangdong Province, is characterized by *Digramma*; and a saddle-shaped corridor north of 42° N latitude is noted by the occurrence of both genera. No control method has yet proved effective.

Microbial diseases

The infectious diseases of grass carp generally fall into several categories: enteritis, gill-rot disease, erythrodermatitis, "stigmatosis", and hemorrhage disease. Enteritis, the etiological agent of which is presumed to be *Pseudomonas punctata f. intestinalis* (Wang, *et al.* 1959), is the most common and detrimental bacterium. The age groups 0+ and 1+ are more susceptible to this epizootic disease than are fish of age 2+. The disease is rampant from March to July at temperatures of 22-28°C; when the water temperature rises above 28°C in August, the disease begins to decline. These bacteria inhabit the intestine of grass carp in a state of "balance of symbiosis" and become pathogenic only when the environment is favorable. However, a chronic viral infection may also be an inducing factor (Nie pers. comm.). Thus, disagreement exists over the etiological agent of this disease; it may be a virus or a bacterial and viral disease complex.

Gill-rot disease, caused by *Flexibacter columnaris,* is widespread among grass carp fingerlings up to the 2+ age group. Diseased fish can be identified by the presence of necrosis at the tips of the gill filaments, with an accompanying accumulation of mucous and debris. The disease occurs in spring and lasts throughout autumn, with an optimal water temperature of 28°C. It continues developing at 37°C but is inactive when the temperature falls below 5°C. *Flexibacter* is sensitive to many antibiotics, sulfa-groups, and Chinese herbs; 0.04 unit/ml of erythromycin, 0.1 unit/ml of penicillin, 0.2 unit/ml of tetran, 0.4 ppm of furacillin, and 1 ppm of sulfathiazole inhibit the growth of this microbe (Ho and Dan 1985).

Another epizootic disease, erythrodermatitis, whose etiological agent is *Pseudomonas fluorescens* (see Wang 1958), is a subacute to chronic disease of the skin. It usually occurs synchronously with enteritis.

Another bacterial disease, "stigmatosis", common in silver and bighead carp, is characterized by the formation of a red stigma or spot on the body surface. The cause of this disease is *Aeromonas punctata subsp. punctata* (see Xu, *et. al.* 1980). For many years this disease has infected age 2+ grass carp and broodfish in our experimental fish farm in Guangzhou.

Hemorrhage of grass carp, a viral disease causing massive mortality of fingerlings, but less mortality of yearlings, has been studied extensively by both the Hydrobiology and Virology Institutes, Academia Sinica, Wuhan, in recent years. The etiological agent was identified as a reovirus. The main symptoms of this disease are exophthalmos and the presence of hemorrhagic areas at the base of the fins and on the gill covers. Hemorrhage may also occur in the musculature, mouth cavity, intestinal tract, liver, and kidney. The virus was replicated in GCG (grass carp gonad) and GCF (grass carp fin) monolayer cell lines and marked pathologic effect appeared about 3-4 days after inoculation and incubation at 28°C. The purified virus particle was icosahedral-shaped, about 70 nm in diameter, and contained a double-shelled capsid. Nucleic acid analysis indicated that the virus had ten segments of double stranded RNA. Immunological studies have been carried out by injecting inactivated vaccine prepared from the liver and spleen of diseased fish into healthy fish. About 80% immune effect was achieved and the immune duration lasted for as long as 14 months (Chen 1985).

Prophylaxis against the main microbial diseases of grass carp has been widely practiced since the late 1960's. Intraperitoneal injection of tissue suspensions prepared from the liver and kidney of diseased fish was used routinely in the spring to prevent their occurrence. This technique has proved effective to a certain degree, both for prophylaxis and treatment. Its advantage is its simplicity; it can be prepared by the fish farmers themselves. However, the method also showed some disadvantage, tissue suspensions prepared from infected fish from one pond may be ineffective in another pond. The technique is further complicated by the fact that it is difficult to procure large quantities of fresh infected materials before the outbreak of an epizootic.

Nutritional diseases

Fish disease may also be caused by an imbalance in the major dietary components of pellet feed. The use of pellet feed in recent years in China has led to cases of lipoid liver degeneration, retarded growth of grass carp, and inferior quality flesh. Our laboratory has conducted the following studies in nutritional pathology: 1. study of the lipid content of liver; 2. histological and electron microscopical studies on the structure of the hepatopancreas; 3. study of 18 levels of enzyme activities; 4. study of biochemistry indices in blood serum; and 5. investigation of three stages of lipoid liver degeneration (see Lin 1985). Daily nutritional requirements of grass carp and mud carp, *Cirrhina molitorella* (Cuvier and Valenciennes), have been studied with the aim of determining a scientific formulation of pellet feed to promote fish production.

Conclusions

Research work, both theoretical and practical, on warm water fish diseases in China has a history of about 30 years. The successful control of some major diseases has remarkably increased the survival rate of grass carp, a key component in polyculture in China, from 10-15% in the early 1950's to 90% in recent years, with unit-product increases of from 225 kg/hectare to 900 kg/hectare. Yet, the fight against diseases "... is in a constant state of flux, some old diseases alter, while some new diseases appear" (Cockburn 1963). As a result of the development of aquaculture, some exotic fishes have been imported without strict quarantine, and presently, China lacks the capability to test for latent diseases. This situation calls for the training of researchers, who should possess a working knowledge of fish diseases occurring outside China.

Aquaculture is a complicated field of interdisciplinary scientific research, and collaboration among nations is of great importance for the exchange of valuable ideas and the solution of problems of common interest.

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CURRENT FISH HEALTH PROBLEMS IN INDONESIA

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Aquaculture plays an important role in the life of the Indonesian people, for whom it provides a source of revenue and protein. Consequently, the government has embarked upon a program to intensify fish culture. Production in various aquaculture systems has been doubled through this program. However, as in all other countries, production is limited by the problem of diseases and parasites.

The first recorded outbreak of parasitic disease in Indonesia occurred in 1932 (see Sachlan 1952) when an epizootic of ichthyophiriasis caused mortality in cultured stocks of tawes (*Puntius javanicus* (Bleeker)), kissing gouramy (*Helostoma temmincki* (Cuvier and Valenciennes)), and giant gouramy (*Osphronemus gouramy* (Lacépède)). No further records of outbreaks of disease in aquaculture systems appeared until 1970, when an epizootic of the parasitic copepod *Lernaea cyprinacea* L. reduced the fry production of *Cyprinus carpio* L. and *P. gonionotus* (Bleeker) in Java by 30%, killing an estimated 1.48 billion fry (see Kabata 1985).

During 1980 to 1983, Indonesia suffered a series of serious outbreaks of epizootic ulcerative syndrome which caused wide-spread fish kills. In 1980, losses of *C. carpio* brood stock were estimated to have a value of two million U.S. dollars. Affected fish showed hemorrhage, large ulcers on the body surface, and erosion of the tail. Many species of fishes were affected, including snakehead (*Ophicephalus striatus* Bloch), walking catfish (*Clarias batrachus* (L.)), swamp eel (*Fluta alba* Zuiew), and giant gouramy. Six species of bacteria were isolated from diseased fishes, but only three species, *Aeromonas hydrophila, A. salmonicida,* and *Pseudomonas fluorescens*, were considered responsible for the disease (Angka, *et al.* 1982).

Other pathogens have also been implicated as causal agents of mortalities in common carp hatcheries and rearing ponds. *Myxobolus* sp. and *Myxosoma* sp. have caused losses as high as 60-90% (Djajadiredja, *et al.* 1983). These parasites may be highly important to carp culture since no chemicals can be used to eradicate them from infected fish.

Other parasites, such as trichodinids, monogeneans, and argulids were commonly observed on fry. Although no study has been done regarding the pathogenicities of these parasites to fry in Indonesia, the literature mentions that they may cause serious problems (see Kabata 1985).

The Government of Indonesia took immediate action to combat these problems. Some actions were successful; others failed. Myxosporea are still a major obstacle for the development of intensive fish culture in Indonesia.

Currently Indonesia faces a problem of spinal curvature or "crook-back" syndrome of the highly important cultured catfish *Clarias batrachus*. This paper reports on the present state of knowledge on this abnormality, based mainly on the unpublished work of S. L. Angka, G. T. Wongkar, and W. Karwani of the

Institute Pertanian Bogor. Information on recent outbreaks of epizootic ulcerative syndrome occurring in populations of wild fishes is also presented, based on an unpublished report of the National Freshwater Aquaculture Centre, Sukabumi.

Crook-back syndrome

No work has been done on the epizootiology of this abnormality. Therefore, no exact account on its prevalence and geographical distribution in Indonesia can be given. However, a prevalence of 50% (83 of 165 fish) was observed at the IBP Faculty of Fisheries *Clarias* breeding pond (unpubl. data). Based on observations of the author, affected fish could be easily found in both breeding ponds and growing ponds in Java.

Affected fish show curvature of the vertebral column, which can be in the tail region, at mid-body, or at just posterior to the head. Individual fish can have either one, two, three, or four curves along the body.

Various bacteria were found in otherwise healthy fish displaying spinal curvature. These were *Pseudomonas* sp., *Aeromonas hydrophila, Corynebacterium* sp., and *Micrococcus.* All these bacteria are also commonly found in fish suffering from epizootic ulcerative syndrome. Whether there is a correlation between the occurrence of these bacteria and spinal curvature syndrome is unknown. As mentioned in the literature, spinal curvature could be due to inadequate nutrition (Anon. 1981; Kabata 1985).

Recently, some methods of hematological investigation have been developed to aid in the diagnosis of fish diseases. The blood picture of normal (healthy), ulcerated, and crooked-back fish is presented in Table 1.

Table 1. Blood picture of normal, ulcerated, and crooked-back *Clarias batrachus*

Blood parameter	Normal	Ulcerated	Crook-back
Hematocrit (%)	30.8-45.5	34.4-48.2	38.1-49.3
Hemoglobin (gr/100 ml)	10.3-13.5	10.9-13.0	12.0-14.0
Erythrocytes (x 10^6/ml)	1.97-3.49	1.90-3.47	2.75-3.38
Leucocytes (x 10^3/ml)	1.12-3.52	3.6-3.08	3.64-7.56

Although no statistical tests were conducted, from the table it can be seen that the number of leucocytes appears to be higher in crooked-back fish than in normal or ulcerated fish. The significance of this, however, is not known.

Outbreaks of epizootic ulcerative syndrome in open waters

Since the 1980 to 1983 outbreaks of epizootic ulcerative syndrome in cultured fishes, infections have been seen in wild fish in open waters. In 1983, mortalities were recorded in Lampung Province, Sumatra. The affected fishes were swamp eel, snakehead, and catfish. Bacteria have been implicated as causal agents. No data is available regarding the extent of losses.

In 1984, an outbreak of the disease was reported from various waters in central Kalimantan. Mortalities were observed, although no data regarding the numbers of fish killed is available. Bacterial infection was again blamed. The affected fish were various cyprinids, snakehead, and swamp eel.

Also in 1984, mortalities were recorded from various lakes in Jambi Province, Sumatra. No data is available regarding the number of mortalities. The affected fishes were mostly cyprinids. *Aeromonas hydrophila* and *A. salmonicida* were isolated from moribund fishes.

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CURRENT FISH DISEASE PROBLEMS IN MALAYSIA

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Fish is one of the cheapest sources of protein, particularly to the rural population. However, in recent years its availability has declined rapidly. As a result of this decline, the Government of Malaysia has given high priority to aquaculture as a means of increasing fish production.

Aquaculture is a relatively young industry in Malaysia, being first introduced in the early 1900's with the culture of common carp (*Cyprinus carpio* L.) in abandoned mining pools. More than 19 species of finfish and shellfish are now cultured in a variety of systems throughout the country.

In 1984, aquaculture contributed about 10% of the total fish production in Malaysia, with a value of about $69 million Malaysian ringgit (MR). The bulk of this production (63,580 t) is derived from the culture of cockles, *Anadara granosa* (L.), valued at MR$27 million. Freshwater fish culture contributed about 11,900 t valued at MR$24 million; whereas marine cage culture contributed about 800 t valued at MR$7 million.

The government is intensifying its efforts to expand this industry through providing technical assistance to fish farmers, increasing production of fry in various hatcheries, and expanding the number of ponds and cages. It is well known that intensive fish farming inevitably encounters disease problems which can be a major threat to increased fish production. The high stocking densities often practised in intensive fish farming encourage the spread of infections by parasitic, bacterial, and viral pathogens.

In this paper, we will deal primarily with finfish diseases and exclude crustaceans and other invertebrates from our deliberation. The main freshwater species cultured are common carp *(Cyprinus carpio),* Javanese carp (*Puntius gonionotus* (Bleeker)), giant gouramy (*Osphronemus gouramy* (Lacepede)), snakeskin gouramy (*Trichogaster pectoralis* (Regan)), Nile tilapia (*Oreochromis niloticus* (L.)), grass carp (*Ctenopharyngodon idella* (Cuvier and Valenciennes)), bighead carp (*Aristichthys nobilis* (Richardson)), catfish (*Pangasius pangasius* (Hamilton)), and jelawat (*Leptobarbus hoeveni* (Bleeker)). The first five species are bred in various government fish hatcheries and distributed or sold to fish farmers in various parts of the country. The last four species are imported from Thailand, Indonesia, Hong Kong, or Taiwan.

The principal marine fish species cultured in floating cages are silver seabass (*Lates calcarifer* (Bloch)), greasy grouper (*Epinephelus salmoides* (Maxwell)), golden snapper (*Lutianus johni* (Bloch)), and fourfinger threadfin (*Eleutheronema tetradactylum* (Shaw)). Seabass and grouper fry are imported mainly from Thailand, whereas snapper and threadfin are captured in local coastal waters. Thus, a substantial number of fish cultured locally are imported, without any proper quarantine requirement upon entry into Malaysia or health certification from the country of origin. As such, pathogenic organisms can easily be imported along with the fish.

Present status of fish disease research

The study of fish parasites has been carried out for quite some time in Malaysia. Most early studies dealt mainly with taxonomic descriptions of parasites. The systematic study of fish disease is a recent occurrence in Malaysia, brought about by the increased intensity of the aquaculture industry. Currently only two research institutions (Fisheries Research Institute in Penang and Freshwater Fisheries Research Station at Batu Berendam) and three universities (Universiti Sains Malaysia, Universiti Pertanian Malaysia, and Universiti Malaya) are involved in the study of fish parasites and diseases. None of these centres are involved in the routine diagnosis of disease outbreaks, but may provide assistance when called upon to do so. Samples of diseased fish are sent by the Fisheries Department to the Government Veterinary Department for diagnosis. There have been only a few documented reports of epizootics. This may be due to farmers not reporting cases to the relevant authority, as well as to the lack of a centre specifically for fish disease study.

Available information on fish diseases in Malaysia was presented by Suhairi Alimon *et al.* (1983) and Mohamed Shariff *et al.* (1979) at the IDRC-sponsored workshops held in Jakarta and in Cisarua, Indonesia, respectively. From these reports, it appears that diseases that affect cultured fishes are caused by bacteria (*Vibrio* sp., *Pseudomonas* sp., and *Aeromonas* sp.), protozoa (*Chilodonella hexasticha* (Kiernik, 1909); *Ichthyobodo* sp.; *Henneguya shaharini* (Shariff, 1982); *Epistylis* sp.; *Trichodina* sp.; *Piscinoodinium* sp.; and *Zoothamnium* sp.), and parasitic crustaceans (*Nerocila sundaica* Bleeker, 1857; *Lernaea cyprinacea* L.; *Argulus japonicus* Thiele, 1900; and *A. indicus* Weber, 1892). In addition to the two previous reports, Leong (1979) reviewed and summarised the knowledge on fish parasites in Malaysia. A total of 24 species of parasites (five trematodes, six cestodes, eight nematodes, three acanthocephalans, and two crustaceans) were recorded from 13 species of freshwater fishes. From 13 species of marine fishes, 14 species of parasites (eight trematodes and six nematodes) were recovered. Most of these studies dealt mainly on parasite taxonomy, and little or no information was given on the prevalence, intensities, or distributions.

In order to implement an effective fish health program in Malaysia, systematic studies on parasites and diseases must be undertaken. The main objective of these studies should be to inventory parasites and bacterial diseases in both cultured and wild stocks of freshwater and marine fishes. These studies should also examine fish imported for aquaculture to identify known and potential pathogens and to recommend regulations to restrict their introduction and spread.

In any of these studies, the baseline data should provide the prevalences and intensities of infection of the parasites found. If possible, an estimate of the size of the fish populations in the study area should also be provided. These data can then be used to estimate the population of each species of parasite in the ecosystem.

We will restrict our review of the current status of fish diseases in Malaysia to the period from 1983 to the end of 1985, and update the current status of other diseases and parasites which did not appear in the two previous reviews. The government hatcheries appeared to be free from disease outbreaks during these years, except at Tapah Breeding Station. At this station, an outbreak of disease caused by the protozoan *Ichthyophthirius multifiliis* Fouquet, 1876 tended to occur during the rainy season at the end of each year, around December-January. The protozoan affected mainly *Puntius gonionotus*, while other species remained free from infection.

The paddyfield catfishes *Clarias batrachus* (L.) and *C. macrocephalus* Günther have the potential to be intensively cultured in Malaysia. *Clarias batrachus* had been intensively cultured in Thailand for quite some time, where disease has been a major problem. The results of a baseline study of the parasites of these two catfishes were reported by Zaman and Leong (1985). A large percentage of the two species was infected. In Kedah, 89.4% of *C. batrachus* was infected, with a mean intensity of 8.1. In Perak, 72.5% of *C. macrocephalus* was infected, with a mean intensity of 8.6. In *C. batrachus*, 19 species of parasites were recovered, with the caryophyllid cestode *Bovienia serialis* (Bovien, 1926) being most abundant. Seventeen species of parasites were recovered in *C. macrocephalus* from both states of Kedah and Perak, with the cestode *Lytocestus lativitellarium* Furtado and Tan, 1973 being most abundant. The seasonal occurrence of various parasites and their maturation in these two catfishes has also been studied. This data base on the parasites in paddyfish catfishes provides a clue to the parasite fauna of these fishes in their natural habitats.

Interest in *C. macrocephalus* has been shown by many farmers in Perak, resulting in a field trial of intensive culture of this species by the Perak Government, made possible through a technical service package provided by USM. This package consists of technology for seed production which, when developed, will be transferred to fish hatcheries at Enggor, evaluation of pond productivity, and disease control. It is hoped that disease outbreaks as experienced in Thailand will not occur here.

The parasites of bighead carp and grass carp imported from Taiwan and Hong Kong were reported by Faizah (1985). A total of 14 species were recovered, of which *Dactylogyrus* spp. (prevalence of 52.6% in bighead carp and 64.4% in grass carp) and *Trichodina* sp. (30.6% in bighead and 47.8% in grass carp) were the most common species encountered. Other parasites reported in the study were *Sanguinicola* sp., *Ichthyophthirius multifiliis, Chilodonella* sp., *Lernaea cyprinacea, Gyrodactylus* sp., and *Piscinoodinium* sp.

On the other hand, there are very few reports on the diseases caused by bacteria and viruses in Malaysia. Wong and Khoo (1978) reported the occurrence of *Aeromonas hydrophila* from the internal organs of marbled goby, *Oxyeleotris marmoratus* (Bleeker), *Vibrio* sp. from diseased *Epinephelus salmoides* cultured in cages, and *Aeromonas* sp. and *Pseudomonas* sp. from diseased *Trichogaster pectoralis.* Wong *et al.* (1979) identified *V. parahemolyticus* as the cause of 'red-boil disease' or vibriosis in grouper.

Since 1976, the bacterial diseases of freshwater and marine fishes were studied by us at the School of Biological Sciences at Universiti Sains Malaysia (USM) in Penang. Table 1 shows data collected between 1976 and 1979 on diseases of fishes that may have been caused by bacteria. The bacteria isolated from freshwater fishes belonged to the genera *Aeromonas* and *Pseudomonas*, while marine fishes were mainly infected by *Vibrio*.

Table 1. Bacteria isolated from various species of diseased freshwater and marine fishes of Malaysia during 1976-1979

Date	Fish species	Symptoms	Bacteria isolated	Tissue habouring the bacteria
6/4/76	*Trichogaster trichopterus*	Body lesions	*Pseudomonas, Aeromonas,* and others	Kidney, body lesions
3/4/76	*T. pectoralis*	Body lesions	Not identified	Kidney, body lesions
12/8/76	*T. pectoralis*	Hemorrhage at tail, fins, and posterior of body	*Pseudomonas, Aeromonas*	Blood, kidney, liver
26/4/76	*T. pectoralis*	Hemorrhage at tail, fins, and posterior of body	*Pseudomonas, Aeromonas* and others	Blood, kidney, liver
29/9/77	*T. pectoralis*	Hemorrhage at tail, fins, and posterior of body	*Pseudomonas, Aeromonas*	Muscle lesions, blood
24/4/76	*T. pectoralis*	Hemorrhage at tail fins, and posterior of body	*Pseudomonas, Aeromonas*	Blood, kidney, liver
5/4/76	*Aplocheilithys* sp.	White lesion on mouth	*Aeromonas* and myxobacteria	Mouth lesion, kidney
14/5/76	*Oxyleotris marmoratus*	Swollen abdomen, dropping scale	*A. hydrophila* *A. punctata*	Blood, spleen, liver, kidney
10/1/78	*Cyprinus carpio*	Body deformed, thin with protu-ding eyes	*Pseudomonas, Aeromonas,* and others	Blood, liver
5/1/78	*C. carpio*	Swollen abdomen, scales protruded, ascites	*Aeromonas*	Blood
5/1/78	*Pterophyllum dumerilli*	Swollen abdomen, ascites	*Aeromonas*	Blood
27/7/77	*Ophicephalus striatus*	Posterior body swollen, with reddish spots	Not identified	Muscle, lesions
3/2/79	*Carassius auratus*	Swollen abdomen, protrusion of scales, hemorr-hage at base of tail	*A. hydrophila*	Abdominal fluids
6/1/78	*Epinephelus salmoides*	Hemorrhagic lesions on body, fin and tail rot	*Vibrio*	Kidney, liver, blood
2/1/79	*Leptobarbus hoeveni*	Body hemorr-hagic, scale loss, tail and fin rot, swollen gall bladder	*Aeromonas, Pseudomonas*	Blood, kidney, gall bladder
28/4/76	*E. salmoides*	Hemorrhagic lesions, fin and tail rot	*Vibrio*	Blood, liver, kidney

From 1978 onwards, we concentrated our efforts on methods of disease control, especially through vaccination. Several dissertations involving freshwater fishes (Siti Rohana 1977, Cheah 1979, Yeap 1980, and Khoo 1980) and marine fishes (Ong 1979, 1984) have been written on this topic. Recently, Ong and Wong (1985) presented a paper on the vaccination of grouper against vibriosis. The vibrio vaccine appears to be effective in reducing mortalities in the laboratory. However, it has not been tested in the field. A field trial will probably be carried out after our present inventory of the bacterial flora of marine fishes is completed.

In August 1983, a large number of 15 cm grouper imported from Thailand for cage culture at Sungai Merbok contracted disease and died soon after their introduction into the cages. Diseased fish showed symptoms characteristic of vibriosis — red spots on the body, erosion of the caudal fin, and body lesions. Some fish were examined and *Vibrio* sp. was isolated.

In July 1985, a large variety of fish, such as tenggalan (*Puntius bulu* Bleeker), kelan (*Tor tambriodes* Bleeker), lampam (*Puntius* sp.), and catfish (*Pangasius* sp.) kept in ponds at USM died suddenly without showing any symptoms of disease. On close examination, the dorsal and caudal fins of these dead fish had air bubbles. The dissolved oxygen in the ponds was measured and the water found to be supersaturated. It was thus suspected the fish died of air bubble disease, caused by supersaturation of dissolved oxygen.

In August 1985, the International Development Research Centre (IDRC) provided funding for research on marine fish diseases to USM. One of the objectives of this study is to identify the parasites and bacterial diseases of marine fishes cultured in floating cages in Kedah, Penang, and Perak. Marine fishes cultured in floating cages are mainly greasy grouper, silver seabass, and golden snapper. Most of the grouper and seabass are imported for cage culture, whereas snapper is caught locally. In May and October of 1985, large numbers (up to 50%) of seabass died in their cages during the first week after their arrival from Thailand. All fish examined were infected with parasites and bacteria, the most common being bacteria belonging to the genus *Vibrio* and the parasites *Cycloplectanum latesi* Tripathi, 1957; *Pseudometadena celebesensis* Yamaguti, 1952; *Bucephalus* sp.; *Rhipidocotyle* sp.; and *Raphidascaris* sp. Almost all imported seabass fry are infected with *C. latesi.*

In August 1985, a disease outbreak in grouper cultured in cages occurred at Kuala Sangga, Perak. The fry had red spots on their bodies and opercula, and the body surface had bruises, indicating that the fish had been rubbing against the sides of the cage. Parasitological and bacteriological examinations indicated the presence of *Vibrio*, and large numbers of the monogenean *Cycloplectanum epinephali* Yamaguti, 1938 on the gills. In this outbreak, about 30,000 grouper fry were lost.

A few fish farmers in Penang bought about 6,000 grouper fry from Kuala Sangga, Perak for cage culture in November, 1985. Within a week, 90% of the fish were dead. Examination of the moribund fish revealed that they were infected with *Vibrio* and large numbers of *C. epinephali.*

In all of the three disease outbreaks cited above, the death of the fish could be due to the heavy intensities of monogenean infections, followed by secondary infections of *Vibrio.*

In as far as marine fish cultured in cages are concerned, a large proportion of newly arrived fry typically die during the first two weeks. Seabass fry harbour the protozoans *Trichodina* and *Cryptocaryon*, the monogenean *Cycloplectanum latesi*, and the bacterium *Vibrio*. Once the fry have survived the first two weeks after their arrival, they have a good chance of reaching marketable size.

For grouper, the disease pattern is slightly different, in that vibriosis tends to occur throughout the grow out phase in the cages. Under some conditions of environmental stress, disease will occur. Grouper also have large numbers of *C. epinephali* on their gills.

Economic impact of disease

There have been few documented cases of epizootics due to fish disease in Malaysia. As such, it is extremely difficult to assess the economic impact of disease. However, cases occurring since 1985 can be assessed.

From our initial survey, it is obvious that the success of aquaculture in Malaysia is very much dependent on the survival rate of the juvenile fish. In this paper, we will restrict our discussion only to the economic impact of disease on marine cage culture of finfish, based on data that we have collected from two case studies and on other information obtained during discussions with farmers in the states of Penang, Perak, and Kedah. One case study involves a privately owned farm, while the other involves a government assisted farm. It is clear that privately run farms generally fair better than government assisted farms in both management and maintenance. The annual mortality rate at the private farm studied by us is around 40%, while at the government assisted farm it is 75%.

Column 2 of Table 2 shows that a farm consisting of 24 cages in six floating rafts can stock up to 11,000 juvenile fish, a combination of grouper and seabass, at a total cost of MR$15,700. Costs of labour, feed, maintenance, and other expenses are estimated to be MR$26,000. The total production cost amounts to MR$41,700 for the 9-12 month growing period. At the end of one year, the average selling price per fish is about MR$7.50, which will bring in a total income of MR$82,500 if all fish survive. The maximum potential profit for the year will thus be MR$40,800, providing an average income of MR$3,400 per month.

Column 3 of Table 2 shows the production costs and profits obtained by the private farm at 60% survival rate. The 40% loss is mainly due to diseases or other management problems. The profit obtained at this survival rate is estimated to be MR$13,800 per year, a reduction of MR$27,000 in profit per year from the maximum obtainable, due mainly to diseases and mortality. The monthly income of this farmer is MR$1,150, a reduction of MR$2,250 per month.

Column 4 of Table 2 shows the production costs and profits (losses) of a government assisted farm based on a survival rate of only 25%. It is clear that at this low survival rate the farm is running at a loss of MR$10,575 per year or $881.25 per month. The total loss including the potential profit to be made if no mortality occurs, amounts to MR$51,375 ($40,800 + $10,575) per year, a very large sum in view of the low income of the fish farmer, which is approximately $200-300 per month, obtained from their normal fishing activities other than cage culture.

Table 2. Estimated production costs and profits (losses) of a cage-culture farm consisting of six floating rafts or 24 cages. (All figures in Malaysian Ringgit)

	Percentage of Fish Surviving to Market 100%	60%	25%
Number of fish	11,000	6,600	2,700
Value at market ($7.50/fish)	$82,500	$49,500	$20,625
Expenditures			
Labour	9,000	9,000	9,000
Fish food	14,000	8,000	3,500
Purchase of fry	15,700	15,700	15,700
Maintenance	3,000	3,000	3,000
Total production costs	41,700	35,700	31,200
Net profit or loss	+40,800	+13,800	-10,575
Average monthly income to farmer	3,400	1,150	nil

Table 3 shows that in 1982 there were a total of 2515 cages in Peninsular Malaysia, distributed mainly in the states of Penang, Perak, Kedah, and Johore. Since then, the total number has increased several fold, especially with the active participation of the Fisheries Development Authority of Malaysia in the past few years to assist the conversion of traditional fishermen to fish farming. The estimated number of cages owned by private farmers in 1982 was about 70% (1,760 cages) of the total, while the remaining 30% (755 cages) belonged to government assisted farms, though the latter may now have increased substantially.

Table 3. Number of operators and cages of marine fishes in Peninsular Malaysia in 1982

State	No. of operators	No. of cages
Perlis	0	0
Kedah	45	248
Penang	125	976
Perak	33	664
Selangor	11	40
Negri Sembilan	0	0
Malacca	0	0
Johore	78	483
Pahang	3	12
Trengganu	2	20
Kelantan	18	72
Total	315	2,515

Based on the 60% survival rate for a private farm, a loss of MR\$27,000 (\$40,800-\$13,800) in income for every six rafts (24 cages) can be attributed to diseases and associated problems. The loss per cage is estimated at MR\$1,125 and the total loss in potential income for the private farms in Peninsular Malaysia was therefore around MR\$1,980,000 (\$1,125 x 1,760) in 1982 alone.

The 25% survival rate at the government assisted farms will result in a loss of MR\$65,125 (\$51,375 + \$10,575) per every six rafts, or \$2,140.63 per cage. The total loss for all government assisted farms in Peninsular Malaysia in 1982 was estimated at MR\$1,616,175.60 (\$2,140.63 x 755).

The annual loss due to diseases or associated problems will total MR\$3,596,175.60 (\$1,616,175.60 + \$1,980,000) for all farms in Peninsular Malaysia in 1982. This figure will increase further as cage culture activity is further encouraged.

From the above calculations, it is obvious that diseases and other associated problems have a tremendous economic impact on the aquaculture industry in Malaysia. The break-even point at the present moment is at a survival rate of about 50%, which is very close to the present 60% survival rate obtained by the private farms. Any further reduction in survival or a decrease in selling price will make cage culture non-profitable and could close down all the existing farms. In view of the potential seriousness of this situation, it is desirable to concentrate our present research efforts on finding ways to increase the survival rate, both during transportation and at the farms. An understanding of the nature of the pathogens is of cage cultured fishes is necessary if we are to make cage culture a more successful venture in the future.

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CURRENT FISH DISEASE PROBLEMS IN THE PHILIPPINES AND THEIR ECONOMIC IMPACT

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The aquaculture industry accounts for 10% of the total fish production in the Philippines (Librero and Perez 1985). The need to increase production levels or capacity has led to intensification of culture methods, through the use of higher stocking densities. However, when population densities are increased, there is also a corresponding increase in the risk of disease outbreaks. Diseases may cause direct mortalities, affect growth and weight, or cause physical deformities (growths, tumors, lesions, ulcers) which limit the marketability of fish. While disease outbreaks are more common in aquaculture systems, problems may also occur in fish grown in their natural environment, as was observed in the recent disease problem at Laguna de Bay.

Laguna de Bay fish kills

Very recently, between early December 1985 and early February 1986, the Philippines experienced a serious outbreak of epizootic ulcerative syndrome in Laguna de Bay. The 90,000 ha Laguna de Bay, the largest and most productive lake in the Southeast Asian region, provides 60-80% of the fish needs of Metro Manila and nearby areas (Orig 1986c). Around 15,000 lakeshore families from the towns of Cardona, Morong, Pililla, Binangonan, Siniloan, Pakil, Pangil, and Taytay were affected. The disease was observed in 5-40% of the fish population but confined only to bottom-dwelling species like snakehead or mudfish (*Ophicephalus striatus* Bloch), goby (*Glossogobius giurus* (Hamilton-Buchanan)), walking catfish (*Clarias batrachus* (L.)), crucian carp (*Carassius carassius* (L.)), Manila sea catfish (*Arius manillensis* (Cuvier and Valenciennes)), silvery theraponid (*Therapon plumbius* (Kner)), and snakeskin gouramy (*Trichogaster pectoralis* (Regan)) (Orig 1986a). Other species, such as milkfish (*Chanos chanos* (Forskal)), bighead carp (*Aristichythys nobilis* (Richardson)), and Nile tilapia (*Oreochromis niloticus* (L.)), were not affected (Flores 1986).

The disease was characterized by the presence of petechiae and ulcers on the body of the fish, particularly the mandible, the region of the head just behind the eyes, and the caudal region. While researchers at the Southeast Asian Fisheries Development Center (SEAFDEC), the Bureau of Fisheries and Aquatic Resources (BFAR), and the University of the Philippines in the Visayas (UPV) at Diliman have consistently isolated the bacterium *Aeromonas hydrophila* from diseased fish, its exact role as a pathogen has not yet been established (Llobrera and Gacutan unpubl. data; Orig 1986c). *Aeromonas hydrophila* has been frequently associated with bacterial infection only as a secondary invader (Roberts 1978; Lewis and Plumb 1979; Tonguthai 1985). It is a facultative, opportunistic pathogen which causes infections when the host resistance has been lowered by environmental factors such as stress, high organic load, overcrowding, and sublethal oxygen levels.

Aeromonas hydrophila was isolated from the skin lesions and ulcers but not from the blood or the internal organs, indicating that the infection was not systemic (Llobrera and Gacutan unpubl. data). Similar outbreaks in Thailand did not show septicemia or systemic infection except in very serious or advanced stages of the disease (Tonguthai 1985). Lewis and Plumb (1979) have pointed out that *A. hydrophila* may be associated with either local or systemic infections.

External parasites have been suspected to pave the way for secondary bacterial infection by causing damage to the epidermis when they bite or attach to the skin (Tonguthai 1985). *Argulus* and *Gyrodactylus* were associated with diseased fish on some occasions in Thailand. Reports from BFAR also indicated the presence of the crustacean parasite *Argulus* and the protozoan parasite *Trichodina* (Orig 1986c).

Diagnostic capabilities for viral infections of fish are not available in the Philippines, but the possibility that a virus may be involved in the outbreak cannot be ruled out because of the clinical signs and epizootic nature of the disease. Ultra-structural evidence of a possible viral infection during recent outbreaks in Thailand has been found by virologists in that country (Tonguthai 1985).

Over the years, there has been a proliferation of fish pens and cages in the lake and of industrial firms in the area, resulting in overcrowding and pollution. Less than half of the approximately 1,000 factories and firms around the lake practice adequate pollution control measures before discharging their wastes into the lake (Orig 1986b). It is further estimated that about 100 t of garbage and solid waste from the 72 towns of Rizal Province alone are dumped daily into the lake. Non-biodegradable pesticide and insecticide residues from houses, farms, and factories also find their way into the lake, contributing to the decline of water quality. Pesticides and herbicides were considered the major cause of fish kills in Malaysia (Tonguthai 1985).

The building of the Napindan Hydraulic Control Structure (HCS) in Taguig, Metro Manila in 1983 has been identified as the major critical factor in the deterioration of the lake (Flores 1986, Orig 1986c). The HCS was built to prevent polluted water from the Pasig River from entering the lake and to maintain the water quality of the lake, which irrigates approximately 30,000 ha of ricelands (Orig 1986b). With the construction of the HCS, the lake was to become the source of drinking water for the Metro Manila area. Since the construction of the HCS, growth of water hyacinths has not been checked and the water has remained turbid. Primary productivity and fish production declined significantly after the Napindan channel (Pasig River) was closed (Orig 1986c).

The economic impact of the disease directly affected the subsistence fishermen and indirectly, the people involved in fish transport, marketing, distribution, processing, netmaking, and other fishery-related business. An average daily income of ₱80-₱100 (₱20 = US$1.00) declined to ₱30-₱35 during the disease outbreak (Reyes 1986). Affected fish species which commanded ₱25/kg before the disease outbreak cost only ₱8/kg around the lake area, while a ₱30/kg fish in Metro Manila was selling for only ₱15/kg. Even though other species were not affected and appeared normal and healthy, they were still rejected because of consumer wariness. Freshwater fishes coming from other lakes were suspected as well and were also rejected.

While there is a possibility that *Aeromonas hydrophila* may have been introduced into the lake through importation of fish from other countries (e.g., walking catfish and crucian carp) there is no evidence or hard data to support this. Transfer of fish from one area or country to another creates problems as far as *A. hydrophila* is concerned. A given population of fish usually develops resistance against local strains of *A. hydrophila*, but may not be resistant to strains from other waters or areas (Lewis and Plumb 1979). Similar problems have also occurred in Australia, Papua New Guinea, Indonesia, Malaysia, Thailand, Burma, and Laos, suggesting the possibility of an international epizootic (Tonguthai 1985).

Diseased fish can be treated with antibiotics and potentiated sulphonamides, but this is not economically nor logistically practical in this case. Improvement of environmental conditions, reduction of organic and inorganic pollutants, and limiting total areas of pens and cages to minimize overcrowding and stress would probably eliminate similar future outbreaks. It has been suggested that the Napindan HCS be opened during the months of April to July each year, to allow entry of seawater into the lake which might improve hydrobiological conditions.

Soft-shelling disease of giant tiger prawn, *Penaeus monodon* (Fabricius)

Under normal conditions, the exoskeleton or carapace of giant tiger prawn, known locally as sugpo, hardens within 1-2 days after molting, but in some cases it remains soft even weeks after molting. The problem of soft-shelling is common both for extensive and semi-intensive culture systems in Panay and in Mindanao (Baticados pers. comm.).

Investigations have failed to isolate any infectious agent (bacteria, fungus, or parasite) as a possible cause of soft-shelling (Baticados pers. comm.). At least three factors have been identified as causes of soft-shelling: poor soil and water quality, chemical and pesticides contamination, and nutritional deficiency. The last factor may be a major cause, since it has been observed by Baticados (pers. comm.) that soft-shelling can be reversed through manipulation or improvement of the diet.

Prevalence of soft-shelling in more than 10% of the population results in a significant financial loss to prawn farmers, especially large-scale or commercial growers. Normal, healthy prawns sell for at least ₱120/kg (premium price is ₱180/kg) but soft-shelled prawns sell for only ₱90/kg or less. Importing countries often reject soft-shelled prawns or give them a lower grade because of their "inferior" quality, usually lighter weight, and darker, unattractive appearance. Thus, they are sold mostly in local markets. Processing problems are also compounded when prawns are soft-shelled. A commercial prawn farmer could lose at least ₱30,000 for every ton of sugpo harvested if soft-shelling occurs in as much as 10% of the population.

Gas-bubble disease

Gas-bubble disease associated with supersaturation of gases (nitrogen and oxygen) in the water is one of the most important diseases of intensively cultured fish (Roberts 1978). This disease caused cumulative mortalities of from 8-60% of 27-31 day-old milkfish fry reared at the SEAFDEC hatchery facilities in 1983 (Lio-Po 1983). The total number of fry lost was 1,851, amounting only to ₱462.75 (at ₱0.25/fry), the hatchery operation being small-scale. Gas bubbles were observed in the abdominal cavity, and less frequently within the intestine and the eyes of affected fish. The eyes are usually the first organ to show gas bubbles because when the Descemet's membrane is ruptured, the gas bulges the cornea out, creating either a unilateral or bilateral eye abnormality, called exophthalmos or "popeye" (Roberts 1978). Other signs observed in live fish were swollen abdomen, hyperemia of the peritoneal cavity, and hemorrhages at the bases of the fins. Moribund fish showed no schooling behavior and displayed upside down swimming activity.

Supersaturation of dissolved gases may have been caused either by an excessive algal bloom of *Chlorella* which was used as food for the fry or by a leak at the water valve/pipe systems (Lio-Po 1983). The exact physiological mechanism involved in gas-bubble phenomenon is, however, not completely understood (Roberts 1978). The problem can be avoided by proper aeration of the culture water.

Other incidences of gas-bubble disease at SEAFDEC, Tigbauan station have been diagnosed at the Pathology Diagnostic Laboratory (PDL). A serious case caused mortalities of 21,000 12-day old milkfish fry, with losses amounting to ₱4,450. Golden spinefoot (*Siganus guttatus* (Bloch)) broodstocks manifesting blisters and exophthalmos also died from gas-bubble disease, with a mortality rate of 50%.

Other disease problems

A bacterium, *Vibrio* sp. (closely-related to *Vibrio parahaemolyticus* and *V. alginolyticus*), was isolated from eye lesions of juvenile milkfish (polycultured with Indian prawn, *Penaeus indicus* (H. Milne Edwards)) showing varying degrees of eye opacity (see Muroga *et al.* 1984, Pitogo 1984). Injury to the outer corneal layer of the eye may have been caused by direct contact with the rostrum of the prawn; *Vibrio* may have been only a secondary invader. Actual mortalities in the culture ponds were not mentioned but the opaque-eyed appearance of the fish was not attractive.

Vibrio infections are commonly diagnosed at the PDL. One case involved 5-10% mortalities of milkfish juveniles in 1984. Another case caused secondary systemic infection of golden spinefoot juveniles. This particular infection was associated with *Caligus* sp. and nematode infections. The affected areas of the fish showed white spot formations which eventually developed into blisters and open wounds. Mortalities of 10-20% of spinefoot fingerlings from *Vibrio* sp. infection were also associated with nematode, *Caligus*, and *Trichodina* infections.

Infections of milkfish fingerlings by *Aeromonas hydrophila* and a *Pseudomonas*-like bacterium have been related to stress factors during transport from the sea to a freshwater lake (Lio-Po pers. comm.). Mortalities of "hundreds of thousands" of milkfish fingerlings (losses estimated to be more than ₱25,000) one week after stocking in fish pens were reported earlier by Duncan (1974). Lio-Po (pers. comm.) mentioned that transport-stress related infections and mortalities are perennial problems of fish farmers in Luzon, often resulting in losses of thousands of pesos.

When milkfish fingerlings are transported in petuya boats from Bulacan to Laguna de Bay, they are subjected to stress due to high stocking density, a drop in dissolved oxygen levels, an increase in water turbidity after the water hole of the petuya boat is closed, and abrupt changes in salinity (from 15 to 30 then to 0 ppt within 1-3 hrs) (Lio-Po pers. comm.). As a result, the fingerlings become susceptible to infections and suffer mortalities after stocking in the lake.

Baticados and Quinitio (1984) reported an *Amyloodinium*-like protozoan parasite, subsequently identified as *A. ocellatum* Brown and Hovasse, 1946, from the gills of adult grey mullet (*Mugil cephalus* L.) as the cause of mortalities in 1981. The disease outbreak involved six broodstock fish used in a maturation experiment at SEAFDEC, Tigbauan. The parasite caused structural alterations to the gills, affecting osmoregulation and respiration and ultimately causing mortalities. A similar case of *A. ocellatum* infection caused mortalities of 12 adult grey mullet in 1985. The fish, kept in tanks at SEAFDEC's Leganes station, had emaciated bodies with very large heads. *Amyloodinium ocellatum* was recovered from the gills and body surfaces, which showed tumor-like lesions.

Heavy infections by unidentified tapeworms and nematodes resulted in consumer rejection of snakeskin gouramy (Natividad pers. comm.) caught from the Banaoang River in Moncada, Tarlac in 1983. A total of 29 tapeworms were recovered from the intestines and stomach of 21 fish while nematodes were found in the intestinal walls and gills of 89 fish samples. Loss of income due to consumer rejection of the catch was estimated at ₱50,000.

Limited fish kills involving mullet were associated with the recent (1983) red tide blooms of *Pyrodinium bahamense* var *compressa* in the Philippines (Gacutan pers. comm.). Estudillo and Gonzales (1984) mentioned reports of a "scattering of a few hundred" smaller species along the beaches and harbour area where red tide was observed, and that no mass mortalities of fish or aquatic animals occurred during the same period. Fish kills due to algal blooms have been regularly noted in Laguna de Bay, but no hard data on their economic impact are available (Delmendo 1982).

Finally, mass mortalities of *Penaeus monodon* juveniles and post-larvae due to the ectocommensal protozoans *Zoothamnium, Vorticella,* and *Epistylis* and the filamentous bacterium *Leucothrix* frequently occurred at the SEAFDEC, Tigbauan hatcheries in 1984. These organisms usually attached to the gills and appendages of the prawn causing either respiratory problems or difficulties in movement and molting. Financial losses due to mortalities often amounted to thousands of pesos.

Conclusions

Disease outbreaks involve financial losses, either due to direct mortalities or consumer rejection. In most cases, these outbreaks are predisposed by stressors such as poor water quality or deteriorating environmental conditions (Laguna de Bay fish kills), inadequate nutrition (soft-shelling), dissolved gases levels (gas-bubble disease), improper handling and transport procedures, and algal blooms. While control and treatment of these diseases are expensive and difficult, if not impossible, prevention is often easier by maintaining recommended culture conditions.

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CURRENT STATUS OF PROBLEMS RELATED TO MORTALITIES IN FARMED MARINE FOOD FISH IN SINGAPORE[1]

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With the implementation of the Marine Fish Farming Scheme in 1981, netcage farming has expanded to 63 farms in Singapore. The main finfish species farmed are the estuarine or greasy grouper (*Epinephelus tauvina* (Forskal))[2], silver seabass (*Lates calcarifer* (Bloch)), golden or John's snapper (*Lutjanus johni* (Bloch)), red grouper (*Plectropomus maculatus* (Bloch)), and whitespotted rabbitfish (*Siganus canaliculatus* (Park)). In such intensive farming, the opportunity to study and recognize the pathogens infecting these fishes is increased. However, while disease epizootics have not been reported, mortality among newly imported fingerlings can be significant. Other diseases may inflict lesser losses. In 1985, about 150,000 grouper fingerlings and 2.4 million seabass fingerlings were imported from the Philippines (grouper only), Thailand, and Indonesia (see Table 1). It is estimated that there was 35-40% mortality in imported fingerlings, while another 10-15% mortality occurred during culture. The following is an account of the findings of the Primary Production Department over recent years, and of the work done in diagnosing diseases that occur in marine fishes farmed in floating netcages. For additional information on the specific parasites and diseases described herein the reader is referred to Chong and Chao (1986).

Table 1. Summary of main food fish fingerlings imported into Singapore in 1985

Source	Species	
	Grouper (Nos.)	**Seabass (Nos.)**
Philippines	73,482	—
Thailand	79,300	2,443,511
Indonesia	1,096	1,000
Total	153,878	2,444,511

Mortalities due to importation stress

Mortality of newly imported fishes is considered to be the single most important cause of loss to local fish farmers. An estimated 75% of the stock lost

[1]Read by J.R. Arthur.

[2]Editors Note: According to Dr. Chua Thia-Eng (pers. comm.) the correct name for the grouper cultured in Southeast Asia is *E. salmoides*.

during farming occurs in the first three weeks following arrival and stocking in netcages and may be attributed to stress during importation. Fingerlings for stocking in farms are presently air freighted. Except for seabass, which is available from commercial hatcheries, fishes are caught from the wild and are therefore subjected to capture and holding stress prior to export. Subsequently, they are also subjected to stress from transportation and adaptation to a new environment, in this instance floating netcage conditions in local waters.

Some of the effects of stress have been observed in newly imported fishes. Severe irreversible shock is occasionally encountered during release of fingerlings from the packings. This may result in mortalities of up to 50%. Physiological failure probably accounts for the mortalities observed in the first few weeks. The conditions producing stress are mainly those of transport, and include high ammonia, nitrite, and carbon dioxide levels which precipitate altered organ function. For example, the gills of imported fishes often produce excessive mucus which interferes with oxygen uptake. Dehydration often results from extensively damaged skin and the resulting breakdown in kidney function. Under such stress, fish usually refuse to feed, weakening them further and consequently predisposing them to infection.

After several trials, it was found that losses due to the effects described above may be reduced through sanitation treatments. This has been confirmed for grouper fingerlings imported from Philippines. Sanitation includes a preshipment treatment of 10 ppm acriflavine for half an hour, a transshipment treatment of 10 ppm nitrofurazone in the packing water, and an on-farm treatment of 100 ppm formalin for one hour followed by 30 ppm nitrofurazone for four hours. Unsanitized fish have been observed to be more susceptible to protozoal and bacterial attacks.

Diseases due to biological agents

Parasites:

Cryptocaryoniasis, the most commonly encountered protozoan disease, is caused by *Cryptocaryon irritans* Brown, 1951, the marine equivalent of the widespread freshwater pathogen *Ichthyophthirius multifiliis* Fouquet, 1876. Continual feeding by the trophont stage results in the sometimes extensive skin and gill damage caused by this parasite (see Cheung *et al.* 1979). *Cryptocaryon irritans* is not species specific. All marine farmed fishes appear susceptible, but the clinical signs vary considerably. Estuarine groupers display the classical "white spot" typical also of *I. multifiliis*. The "white spots" represent focal areas of individual parasite growth deep within the skin. However in certain cases, for example, re-infection or secondary invasion by bacteria, open ulcers are formed. Seabass seldom display "white spots". Instead, a "wasting disease" of long duration is observed. Affected fish lose their appetite, are lethargic, have opaque eyes, lose scales, and suffer from occasional subcutaneous haemorrhage and fin rot from secondary bacterial infection. Golden snappers are severely affected in the head region, involving loss of skin from the dorsal and opercular areas, giving the fish a bald appearance. All fishes are susceptible to gill infection by *C. irritans*, which results in the disruption of gill function and difficulty in breathing.

A bean-shaped protozoan tentatively identified as *Brooklynella sp.*, is also not species specific. It was first found on imported Japanese red seabream (*Pagrus major* (Temmick and Schlegel)) and was later detected on seabass and grouper. It is found on the gills and skin of affected fish. Clinical signs are similar to those of cryptocaryoniasis except that skin breaks seldom occur and lesions tend to be more dispersed. Subcutaneous hemorrhage is also a more constant feature.

Trichodina sp. infects all fish species observed, but newly imported seabass fingerlings, often reared under brackishwater conditions, are most frequently affected. The parasite is found on the gills and skin. Clinical signs resemble those of brooklynelliasis or may be totally absent.

The monogenean *Diplectanum* sp. is always found on the gills of healthy grouper and seabass. Severe infections are often associated with systemic diseases, such as vibriosis. Another monogenean, *Dactylogyrus* sp., which has been reported to be common on fish in the Southeast Asian region (see Kabata 1985), has been occasionally seen on locally cultured fishes.

The copepod *Ergasilus* sp. (members of this genus are found both in marine and fresh water) is seen occasionally on locally cultured marine fishes, while females of the isopod *Nerocila* sp. infect a wide range of cultured and wild fishes, usually of greater than 50 gm weight. However, male forms of *Nerocila* sp. infect smaller fishes, especially seabass fry held in nursery netcages.

Bacterial diseases:

Bacterial fin rot is frequently encountered following importation and handling, and is due to mechanical injury or tail-biting. By itself, fin rot need not be fatal, however it can lead to systemic bacterial disease if unchecked. Examination of smears from areas of protozoal fin erosion have often revealed an absence of protozoa but an abundance of bacteria comprised of mainly *Myxobacter*-like organisms and some vibrios, pseudomonads, and Gram-positive cocci. It is likely, therefore, that fin rot is derived from the action of such mixed bacterial populations. The predominance of vibrios in bacterial cultures is probably due to their natural presence in seawater, fast growth, and ability to swamp colonies of slower growing bacteria in normal isolation media.

Vibrio parahaemolyticus and *Vibrio alginolyticus* are often implicated in "vibriosis" of local marine fishes. These, and several related species (e.g., *V. harveyi, V. fluvialis, V. marinus*), have been isolated aseptically from diseased grouper and seabass. None of these vibrios can really be identiied with "vibriosis", since artificial transmission of the disease by intraperitoneal injection of bacteria into healthy fish requires very high doses. It is believed that "vibriosis" is generally secondary in nature, occurring as a sequel to trauma or primary infection by protozoa. Nevertheless, "vibriosis", or death attributable to vibrios, probably accounts for a significant proportion of mortalities during importation and handling.

Sporadic streptococcosis has been observed in red grouper and rabbitfish. *Streptococcus* sp., Lancefield Group "C", was isolated from red grouper, while group "L" was isolated from rabbitfish. Systemic infection with few external signs is the norm, although affected fish may be lethargic, with uncoordinated swimming and also corneal hemorrhage. Similarly, few abnornalities are observed in the internal organs.

Fungal diseases:

Icthyosporidiosis caused by the fungus *Ichthyosporidium* sp. has only been found in red grouper. External growth of *Icthyosporidium* sp. is associated with deep erosion of host tissue, causing a "pot hole" lesion which may extend right down to the cranial bones of infected fish. *Ichthyosporidium* sp. is also disseminated widely in the internal organs and musculature. Lumpy granulomas are formed under the skin and the epithelial layers of internal organs, such as the heart and liver. Ichthyosporidosis seems to develop slowly since the disease has been diagnosed only in marketable-sized fish.

Viral diseases:

Lymphocystis disease, caused by an iridovirus, is the only fish disease of proven viral etiology in Singapore. The virus is seen as a polyhedral particle, approximately 0.13 to 0.26 μm in diameter, consisting of an inner DNA core wrapped in an outer protein coat. Infection of susceptible fish skin cells results in accelerated nuclear division without concurrent cytoplasmic division. Giant cells called lymphocysts, resembling little grains, are thus formed. These clusters of transformed cells constitute tumors (nodules) located on the fins and skin.

Seabass appears to be the only locally cultured fish that is susceptible to this disease. Lymphocystis occurs patchily, usually with less than 5% prevalence, and is most frequently encountered soon after importation. It is possible that imported fish harbour the virus in a latent form which is re-activated under the stress of transfer to a new environment. Fingerlings below 10 cm in length may suffer moderate mortalities. Otherwise, infected fish recover completely with no scarring. The virus has been demonstrated to be infectious and water transmissible (Chao 1984).

Mortalities caused by plankton blooms:

Plankton blooms consisting mainly of diatoms and dinoflagellates occur with unpredictable frequency, with each bloom lasting for as long as five days. Tidal currents carry these dinoflagellates and diatoms in cloud-like formations which cover a few hectares at depths down to two meters from the surface, giving the impression of "dirty" water. So far, species of toxic dinoflagellates often associated with "red tide" have not been detected in Singapore waters. The non-toxic dinoflagellate *Cochlodinium* sp. is the principal organism involved in local blooms.

Annual fish losses have, however, been due to such non-toxic plankton blooms. These losses are second only to that of mortalities due to importation stress and are particularly severe at slack tide, when blooms are concentrated at fish farming areas. Immediate fish kills are apparently caused by gill filament clogging and consequent oxygen starvation. A week or two later, deaths from secondary bacterial infections reach a peak. It is likely that fish are severely stressed as a result of exposure to the bloom, which is usually a dinoflagellate. Red groupers are most vulnerable, followed by estuarine grouper, golden snapper, and seabass.

Plankton blooms cannot be predicted, since the triggering factors are not specifically known. Once started, their scale defies physical or chemical control. The protection of farmed fishes therefore necessitates minimizing contact between fish and plankton blooms. A number of methods are being tested for this. They are:

a) using four-metre-deep nets in areas where water conditions are favorable e.g., oxygen level is high at such depth and current is swift. This allows fish to stay below the bloom zone;

b) fixing a two-metre-deep weighted skirt around netcages;

c) pumping air at high pressure and volume from jets around netcages to disperse the bloom and to draw up bottom water by the air lift/venturi principle;

d) drawing water from below the bloom zone with a submersible pump and spraying it onto netcages; and

e) towing farm sections to safe areas.

Method (e) is done as a last resort, since the relevant authorities will have to be notified and other arrangements made. Method (d) does not disperse the bloom well because the submersible pump does not jet out the water and its effect is localised. Method (c) is reportedly effective but costly, since it requires the use of a powerful generator and air compressor. In preliminary trials by the Primary Production Department, method (b) has shown promise for the short term protection of particularly valuable stocks. For longer term protection, such as during periods when the plankton bloom coincides with slack tide, method (a) is probably preferable.

Nutritional diseases

Nutritional diseases are rarely encountered. However, it is usual to observe yellow or pale livers at necropsy which are confirmed by histopathology to suffer from varied degrees of lipidosis. It is thought that this condition is linked to the use of poorly stored trash fish and/or the use of trash fish with a high fat content.

Swim bladder syndrome

This complex problem, involving overinflation of the swim bladder, can affect estuarine groupers ranging from 30 gm to more than 10 kg, but more often affects large-sized fish, like breeders of up to four kg. The more common condition involves a gradual loss of buoyancy control by the fish, which may swim (a) in a head down position near the surface; (b) at the surface with the back exposed; (c) intermittently and erratically on the sides; or (d) upside down, with visibly distended abdomen.

Another set of clinical signs has been observed in larger breeders: the fish lies on its side in a semi-conscious state at the bottom of the netcage, with weak opercular and pectoral fin movement. The swim bladder at this stage is relatively unfilled, with fibrous thickening of the anterior portion and a thin hernia-like posterior portion. The next stage involves a ballooning out of the posterior portion, elevating the affected fish from the sunken position to an upside-down floating position. The syndrome usually affects less than 10% of fish within a netcage. Death is mainly caused by systemic bacterial infection, sunburn, and abrasion from rubbing on the sides of the netcage.

The occurrence of swim bladder syndrome is often widespread over a short period, and approaches an epizootic pattern. However, there is no evidence of pathogen involvement. Postmortem and histopathological examination of diseased fish reveals as a consistent feature well developed vascularization of the swim bladder. The gas of the inflated swim bladder is air-like in composition. Grouper swim bladders are physoclistic and are therefore inflated by transfer of dissolved gas from the blood to the lumen of the swim bladder. Swim bladder syndrome apparently involves excessive secretion of gas and impaired re-absorption and suggests a physiological failure. The reason for this is not known although it has been demonstrated (Kolbeinshavn and Wallace 1985) that the prevalence of swim bladder stress syndrome in arctic char (*Salvelinus alpinus* (L.)) is inversely related to the depth of culture. If the same rules apply, this would explain why estuarine grouper, as the most demersally-inclined farmed species, is most susceptible to swim bladder syndrome under the conditions of a culture system using floating netcages. Seasonal changes (e.g., intermonsoon periods) may also play a part in the triggering process, but the specific factors involved have not been identified.

Conclusions

Losses due to mortalities during importation could be reduced considerably by use of sanitization measures which have been tested successfully on grouper fry and fingerlings imported from the Philippines. It is desirable that similar trials should be conducted on grouper fry and fingerlings imported from other countries, such as Thailand. It is also envisaged that sanitization measures can be incorporated into guidelines for the importation of all live fingerling and fry.

Mortalities caused by plankton blooms are second in importance in terms of fish loss. Research efforts should be directed to identifying the environmental indicators for prediction of these blooms, so that early warning can be given to farmers who could then set up the necessary protective measures.

Swim bladder syndrome warrants further investigation, since the frequency of occurrence is fairly consistent. Parasitic protozoans are the most important group of pathogens. Secondary bacterial infection frequently results from protozoal attack, complicating diagnosis and treatment. It follows that early detection and treatment of protozoal infections will help prevent secondary bacterial infections. It is also useful for farmers to be taught to recognize the clinical signs of protozoal infection and to be conversant with preventive and control measures. Chemotherapy of diseased fish can be an expensive and tedious procedure and at times, results may be less than spectacular. Prophylactic measures, such as sanitization, should be practised as part of every management procedure to minimize cost and effort.

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CURRENT FISH DISEASE PROBLEMS IN SRI LANKA

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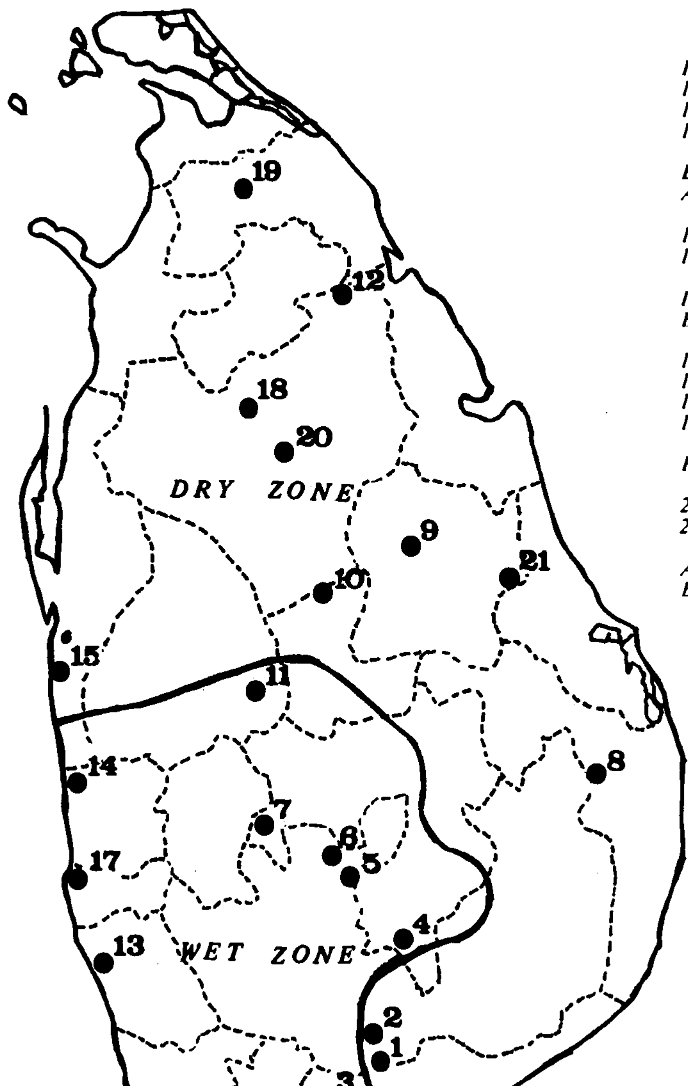
The short history of the Inland Fisheries Development Programme in Sri Lanka shows that the thrust during the past three decades had been towards enhancing fish production in open water bodies, such as reservoirs. This has been achieved chiefly by way of introducing exotic lacustrine fish species, such as the tilapias *Oreochromis mossambicus* (Peters) in 1952, *Tilapia rendalli* (Boulenger) in 1969, and *O. niloticus* (L.) in 1975. Recently, some efforts have been made towards introducing aquaculture methodologies such as pond fish culture, net cage culture, etc., into the country. Polyculture of carps is a major practice that is being presently encouraged. Production of necessary and appropriate seed is one of the most important steps in this direction. This program has been facilitated by the induced breeding success of the exotic carps, such as the Chinese major carps (grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes)); silver carp, *Hypopthamichthys molitrix* (Valenciennes); and bighead carp, *Aristichthys nobilis* (Richardson)); and the Indian major carps (rohu, *Labeo rohita* (Hamilton-Buchanan); mrigal, *Cirrhinus mrigala* (Hamilton); catla, *Catla catla* (Hamilton)); introduced in recent years into the country.

The 15 government fisheries stations (see Figure 1), which are the major fish seed producing centres in the country, have gradually shifted to raising fry and fingerlings in high stocking densities to cater to the increasing demand for fry for culture systems. Hand in hand with this, there has appeared certain fish diseases hitherto unobserved in the country, which cause heavy mortalities. An assessment of the causes of mortality of fingerlings at the fisheries stations indicates that about 37% of all losses are due to disease, thereby causing a loss of about 3 million fry valued at approximately US$68,000 per annum. Disease outbreaks are not significant during the grow out phase, probably because of the extensive methodologies practiced.

Prevalance of fish diseases

In the culture fisheries of Sri Lanka parasitic diseases have been encountered more often than bacterial diseases, the latter being reported only recently. Munasinghe (per. comm.) detected outbreaks of *Lernaea* sp., *Ichthyophthirius* sp., *Myxobolus* sp., and *Argulus* sp. in common carp fingerlings (*Cyprinus carpio* (L.)) at Polonnaruwa Fisheries Station. Fernando and Furtado (1963) reported *Bothriocephalus gowkongensis* Yeh, 1955 (syn. of *B. acheilognathi* Yamaguti, 1934) in indigenous fishes of Sri Lanka and suggested its appearance in the country was related to the introduction of the Chinese carps. Balasuriya (1983) reported the presence of two bacterial diseases, two fungal diseases, and twelve species of ecto- and endoparasites on different species of cyprinids cultured in Sri Lanka and suggested that some of them could have been introduced with the importation of Chinese major carps from the People's Republic of China.



FRESHWATER FISH BREEDING AND EXPERIMENTAL STATIONS

1. *Udawalawe (New)*
2. *Udawalawe (Old)*
3. *Muruthawela*
4. *Beragala*
5. *Nuwara Eliya*
6. *Bambarakelle*
7. *Ginigathhena*
8. *Inginiyagala*
9. *Polonnaruwa*
10. *Dambulla*
11. *Rambodagalla*
12. *Padawiya*
13. *Panapitiya*

BRACKISHWATER FISH BREEDING AND EXPERIMENTAL STATIONS

14. *Pitipana*
15. *Pambala*

INLAND FISHERIES EXTENSION CENTRES

16. *Galle*
17. *Colombo*
18. *Anuradhapura*
19. *Mankulam*

PROPOSED NEW STATIONS

20. *Kalawewa*
21. *Maduru Oya*

ADMINISTRATIVE DISTRICT BOUNDARIES

Figure 1. Map of Sri Lanka showing locations of government fisheries stations

The occurrence of viral diseases in the fish of Sri Lanka has apparently not been recorded, probably due to the lack of facilities for detection.

Recent investigations have shown that three bacterial diseases, two fungal diseases, and 13 parasites occur frequently in the cultured fishes of Sri Lanka (see Table 1). Of these, six parasites and two bacterial diseases cause great losses to the aquaculture industry. These are the parasites *Trichodina* sp., *Lernaea* sp.,

Table 1. Diseases and parasites encountered at freshwater fisheries station in Sri Lanka (after Balasooriya 1983)

Pathogen	Host fish	Location	Fisheries Station where reported	Date reported
Pseudomonas sp.	grass carp (adult)	gills	Dambulla	Aug. 1982
Aeromonas sp.	grass carp (adult)	intestine	Dambulla	April 1984
Saprolegnia sp.	rohu, mrigal, grass carp (fingerlings)	tail, fin base, skin	Dambulla	Feb. 1984
Fungi gen. sp.	rohu (fingerlings), *Puntius* sp.	base of scales	Dambulla	March 1984
Cryptobia sp.	rohu, mrigal, grass carp (fingerlings)	gills	Dambulla	June 1983
Trichodina sp.	rohu, mrigal, common carp, catla, *Labeo dussumieri*, (fry and fingerlings)	skin, gills, fins	Dambulla Udawalawe Nuwara Eliya Polonnaruwa	1983 onwards
Ichthyophthirius sp.	grass carp, rohu, mrigal	skin, gills	Polonnaruwa	1972 onwards
Scyphidia sp.	rohu, mrigal, common carp (fingerlings)	skin, gills	Dambulla Udawalawe	1983 onwards
Myxobolus sp.	rohu, mrigal, common carp (fingerlings and adults)	skin, gills, kidney	Dambulla Udawalawe Polonnaruwa Rambodagalla	1983 onwards
Dactylogyrus sp.	rohu, mrigal, catla, common carp, grass carp, *L. dussumieri*, bighead carp (fingerlings)	gills	Dambulla Udawalawe Rambodagalla Nuwara Eliya	1983 onwards
Gyrodactylus sp.	rohu, mrigal (fingerlings)	gills	Dambulla	1983 onwards
Digenean metacercaria	rohu, mrigal, grass carp, bighead carp, silver carp, common carp, *Puntius* sp. (fingerlings)	gills, skin, muscles	Dambulla Udawalawe Polonnaruwa Rambodagalla	1983 onwards
Ligula sp.	rohu, (fingerlings, adult)	body cavity	Dambulla	April 1983
Lernaea sp.	common carp, rohu, mrigal, *L. dussumieri*, giant gouramy, bighead carp (fingerlings, adult)	skin, base of fins	Rambodagalla Udawalawe Dambulla Nuwara Eliya Ginigathhena	1983 onwards
Synergasilus major	grass carp (adult)	gills	Udawalawe Dambulla	1976 onwards 1984 onwards
Egasilus sp.	catla, grass carp, common carp	skin, fins	Dambulla	1985 onwards
Argulus sp.	common carp	skin	Polonnaruwa	1960 onwards
Isopoda gen. sp.[1]	*O. mossambicus*	gills	Pambala	1985 onwards

[1]This parasite was observed at freshwater reservoirs in the jurisdiction of Pambala Brackishwater Fisheries Station.

Ergasilus sp., *Synergasilus major* (Markevich, 1940), isopods, metacercarial stages of digeneans, and the bacteria *Pseudomonas* sp., and myxobacteria. Since 1982 considerable effort had been made to control these diseases, but these have met with only partial success. Fish kills and slow growth of fish due to diseases are still frequently encountered.

Among the protozoan parasites, *Trichodina* sp. causes severe damage to fry and fingerlings of cyprinid fishes in the fisheries stations. In one instance, when rohu fry in a mud pond at Dambulla Fisheries Station were heavily infected, the estimated number of *Trichodina* on the skin of each 2 cm fish was several thousand, a major contribution to the low survival rate (30%) of these fry.

The most successful method adopted in Sri Lanka for controlling *Trichodina* is to broadcast a mixture of copper sulphate and ferrous sulphate (5:2) at the rate of 0.7 ppm to 1.0 ppm in the pond water. However, complete iradication has not been achieved. It has been observed that *Trichodina* has rapidly spread from one area to another with the transportation of fry and fingerlings.

Three types of copepods, causing damage not only to fingerlings but also to adult fish, were detected in ponds at the fisheries stations and also in the reservoirs. *Ergasilus* sp. outbreaks were observed recently in the fingerling ponds stocked with catla and grass carp at the Dambulla Fisheries Station. Infected fish were lethargic and suffered heavy mortalities during transportation in oxygen-filled polyethylene bags.

Lernaea sp. is common on cyprinid fishes in some fisheries stations. It is believed to have entered the country with the introduction of exotic fishes in the 1950's. Severe mortalities due to this parasite were not observed but its unsightly appearance reduced the market value of the fish. It is feared that this disease could spread to the grow-out ponds, causing severe losses. Tennakoon (per. comm.) observed *Lernaea* on *Etroplus surantensis* (Bloch) in Udawalawe Reservoir, an open water body.

Sinergasilus major, a highly host specific parasite of grass carp (see Bauer *et al.* 1973), was detected at the Udawalawe Fisheries Station in 1976, just one year after the introduction of Chinese major carps from the People's Republic of China. It is practically conclusive that this parasite entered Sri Lanka with the introduction of live adult grass carp from China. In 1979, almost all the brood stock at Udawalawe were heavily infected with this parasite. No mortalities resulted, but high intensities of infection coincided with poor breeding performance of grass carp during this period, affecting the Inland Fisheries Development Programme heavily. Although we have been able to prevent the spread of this parasite to other stations, we have not been successful in completely eradicating it from Udawalawe.

Common methods followed in controlling copepod parasites in fisheries stations are application of Dipterex at the rate of 1 ppm to the pond water and also the practice of bath treatments with $KMnO_4$.

Isopod parasites have become important in some perennial water bodies. They have caused mortalities of *O. mossambicus* and *O. niloticus* adults in two reservoirs in the Pambala area (see Table 1) namely, Katupotha (200 ha) and Siyambalankotuwa (300 ha). Wannigama (per. comm.) observed that continuous restocking of *O. mossambicus* and *O. niloticus* in these reservoirs has not increased production, whereas significant increases in production have been made by restocking water bodies where the parasite is not found. Cage culture trials carried out in one of the reservoirs using *O. niloticus* showed high mortalities due to this parasite. Control is impossible, as it is found in open waters.

Digenean metacercariae are the most widespread parasites in the fisheries stations. One of these metacercariae caused severe losses in fry and fingerlings of all cyprinids reared in the fisheries stations, the gills being the site of infection (Balasuriya unpubl.). The only practical control seems to be eradication of the intermediate host, a snail, from the pond.

Bacterial diseases are mainly found in grass carp reared in fisheries stations. Enteritis of grass carp caused by *Aeromonas punctata f. intestine* (see Anon 1980) caused severe losses in adult fish during epizootics in China. In 1984 about 20% of the grass carp brood stock was destroyed at Dambulla Fisheries Station by this disease. The outbreak was controlled by using sulfaguanidin with the feed. Gill rot of grass carp caused by myxobacteria is the second major bacterial disease found in fisheries station ponds. It is one of the major infectious diseases of grass carp (see Anon 1980). The outbreaks occurred in mud ponds mainly when the organic matter content of the pond bottom was increased. Control was achieved by application of bleaching powder at the rate of 4 kg/ha once every seven days. Avoiding excessive collection of silt in ponds by desilting at appropriate times has a considerable significance as a preventive measure against this disease.

Mass mortalities of fish in open water bodies

Mass mortalities of fish have been reported from time to time in open water bodies, causing great losses to production as well as resulting in environmental pollution. Munasinghe (per. comm.) observed mass mortalities at Padaviya Reservoir in 1962. Again in May of 1983 mass mortalities of *O. mossambicus* and *O. niloticus* were observed at Padaviya Reservoir and Pimburaththewa Reservoir (Polonnaruwa district), destroying about 100 t of fish valued at about US$300,000. During this period even fish captured in gill nets laid by fishermen during the night died and spoiled very rapidly, making the harvest worthless. There are indications that these mortalities could probably have been due to high temperature (recorded water temperature ranged from 34-35°C at 2 m. depth).

A recent case of mass mortalities in a small reservoir (Kandy Lake) has been attributed to oxygen depletion (reported by the National Aquatic Resources Agency of Sri Lanka), a cumulative effect of silting and pollution. The total loss experienced was very high.

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RECENT FISH DISEASE PROBLEMS IN THAILAND

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Aquaculture in Thailand has developed rapidly since the 1960's, and many advancements in fish husbandry have been made. Presently, both intensive and extensive rearing methods are practiced in fresh and brackish water. Systems commonly used in producing fish involve ponds, floating cages, pens, rice paddies, and integrated farms.

At present, the main species of freshwater fishes being cultured in Thailand are snakehead (*Ophicephalus striatus* Bloch), walking catfish (*Clarias batrachus* (L.)) and *C. macrocephalus* Gunther), striped catfish (*Pangasius sutchi* Fowler), Javanese carp (*Puntius gonionotus* (Bleeker)), sand goby (*Oxyeleotris marmoratus* (Bleeker)), snakeskin gouramy (*Trichogaster pectoralis* (Regan)) and grass carp (*Ctenopharyngodon idella* (Cuvier and Valenciennes)). The brackishwater species, which include silver seabass (*Lates calcarifer* (Bloch)) and greasy grouper (*Epinephelus salmoides* Maxwell), are mostly cultured in cages.

During the last few years, fish health has become a major concern to aquaculturists in Thailand. It is well known that diseases are often associated with intensive fish culture. In Thailand, the common practice of intensive culture for many of the species mentioned above is undoubtedly a cause of increased disease events. In addition, the recent promotion of international trade in live ornamental and food fishes may provide an avenue for introducing exotic diseases into Thailand.

The history of studies on fish parasites and diseases in Thailand is relatively short when compared with that of Europe and North America. Early work, which began in the 1920's, involved taxonomic study of the parasites of wild fishes. It was only during the 1960's that investigations on pathogens in aquaculture systems commenced (see Kabata 1985).

Current disease problems

Despite the relatively short history of fish health studies in Thailand, we have recorded many parasites and diseases causing damage to fishes of economic importance.

Snakehead is one of the most economically important freshwater fishes cultured in Thailand. This fish has been cultured intensively for more than 12 years in the central and eastern parts of the country. In the early years, successful snakehead farming brought large incomes to fish growers and its culture expanded rapidly (Boonyaratpalin *et al.* 1985). It appears that this rapid expansion and a lack of understanding of proper pond management were closely related to the many disease problems encountered.

External protozoan parasites commonly found on cultured snakehead belong to the genera *Trichodina, Epistylis, Piscinoodinium,* and *Apiosoma.* Among these, *Trichodina* infecting the skin and gills appears to be the most damaging, especially to fry. Heavy infections not only interfere with respiration, but can also lead to skin ulcerations and frequently to mass mortality (Bumrungsuk 1971). This parasite can severely stress small fish during transport. In Thailand, trichodiniasis always increases during the rainy season. *Epistylis* sp. does not cause direct mortality of fish but causes hyperplasia at the attachment site (Chinabut and Limsuwan 1983a). *Epistylis* sp. was found to cause red spots on the skin of snakehead prior to the severe outbreak of epizootic ulcerative syndrome in Thailand during 1981-1985 (Tonguthai 1985).

The majority of snakehead cultured in ponds were infected by *Pallisentis ophicephali* (Thapar, 1930) (Pawaputanon and Chinabut 1983). A single heavily infected fish could have more than 100 acanthocephalans. With their destructive mechanism of attachment, these parasites may exert a great damaging effect on fish.

Several pathogenic bacteria were discovered in diseased snakehead during the severe disease outbreaks in Thailand in 1981-1985. *Aeromonas hydrophila* was isolated from all samples of ulcerated fish (Tonguthai 1985). However, fish epizootiologists feel that *A. hydrophila* was not the primary etiologic agent, as it is a common inhabitant of tropical waters rich in organic matter (Roberts *et al.* 1986).

Tuberculosis of snakehead caused by *Mycobacterium* was first reported in Thailand in 1983 (Limsuwan *et al.* 1983). Diseased fish show exopthalmos, cloudy cornea of the eye, and have small tubercules or nodules scattered in the liver, kidney, and spleen. This bacterium is most likely transmitted from trash fish which are used for feed. *Haemophilus piscium* was also identified from diseased fish showing signs of starvation and darkened skin color (Boonyaratpalin *et al.* 1983).

Achlya sp. was first reported from fish with skin ulcers during the severe disease outbreak in Thailand (Pittayangkula and Bodhalamik 1983) but it was observed only on fish in the chronic ulcerative stage. Histopathological studies of this fungus (Chinabut and Limsuwan 1983a) found that cells around infected areas showed evidence of severe chronic agranulomatous mycosis.

Viruses were not reported in association with epizootic ulcerative syndrome in snakehead until 1983. Their role in this syndrome has not been conclusively shown. Wattanavijarn *et al.* (1984) reported finding virus-like particles, Jhuingsamarnyat *et al.* (1984) believed that the virus they found was a reovirus or a picornavirus, Saitanu *et al.* (1986) referred to IPN virus, while Roberts *et al.* (1986) reported finding a rhabdovirus.

Clarias batrachus culture in Thailand commenced in the late 1950's and is concentrated in the central part of the country. *Clarias macrocephalus* can be now spawned artificially by the use of hormone. Therefore, its culture is rapidly increasing. *Clarias* culture is very similar to that of snakehead, with high stocking rates of up to 200 fry of 3-5 cm in length per m^2. As disease problems sprang up and caused great losses in *C. batrachus* farming, its culture was largely replaced by snakehead. *Clarias*, especially *C. batrachus*, is always infected by external parasites. *Trichodina* sp. is a major parasite of *Clarias* fry (Bumrungsuk and Chala-aim 1970, Areerat 1978). For example, in 1985 it was found that about 80% of the *Clarias* fry obtained from hatchery ponds in Bangplee, Samutprakarn Province were infected with as many as 200

Trichodina sp. on the gills and skin of each fish (Tonguthai *et al.* 1986). Affected fish showed darkened skin that became frayed and flaky. *Ichthyophthirius multifiliis* Fouquet, 1876 is also a notorious parasite of *Clarias* (Areerat 1978). It seems to exert more severe effects on fry than on adults. Infection often causes massive fry mortalities. Other parasites include *Henneguya* sp. on the gills, *Myxidium* in the gall bladder, and *Myxosoma* in the gonad. Species of *Scyphidia, Apiosoma, Chilodonella,* and *Epistylis*, often present in very small numbers, are not considered a serious problem. Another group of parasites that infects *Clarias* are monogeneans belonging to *Gyrodactylus* and *Dactylogyrus*. The former can appear in significant numbers that cause dark patches on the body surface with areas of sloughing skin. This parasite has been responsible for massive losses of cultured *Clarias* fry (Bumrungsuk 1971, Tonguthai *et al.* 1986).

Ulcerative disease caused by *Aeromonas hydrophila* has been a serious problem in *Clarias* culture, often causing high mortality, in some cases losses reaching 50% (Saitanu *et al.* 1976, Boonyaratpalin and Kesornchan 1980). Bacterial hemorrhagic septicemia most frequently affects 2 week old fry and 3-3½ month old adults. Inflammation may cause the kidney to extend into the pouch under the pectoral fins. Histopathological study showed excessive lymphoid cells in the head kidney and cell necrosis (Chinabut and Limsuwan 1983b). Rattanapanee *et al.* (1976) reported finding *Acrobacter* sp. from the infected area.

Sand goby is an important species for exporting to Singapore, Hong Kong, Malaysia, and Japan, with a value of about 20 million baht in 1985. It commands the highest market price among the freshwater fish species. At present, fish are mostly produced in cage culture along river banks in central Thailand. Bamboo cages, used because they are very convenient and economical, are constructed with such small meshes that only a slow rate of water exchange occurs and much leftover feed is retained. Consequently, poor water quality in the cage creates health problems. Ciliated protozoa do not seem to cause great harm, except for *Epistylis* sp., which infects the skin and leads to bacterial infections similar to the case for snakehead. *Myxobolus* sp. and *Henneguya* sp. were often found in large numbers in the gills and muscles. Chinabut (1980) surveyed parasites that infected sand goby in natural waters and found that the prevalence of infection by *Henneguya* sp. reached 84%; in some cases 600 cysts/fish were observed. *Lernaea* sp., *Ergasilus* sp., and *Aega* sp. were also found, as were *Spinitectus* sp. and *Pallisentis ophicephali* in cultured sand goby fed with trash fish (Chinabut and Sirikaron 1976).

Mortalities of sand goby cultured in cages were not attributed to parasites but were associated with infection by *A. hydrophila*. Infections were indicated by deep ulcers, and skin and muscle necrosis. *Corynebacterium* sp., *Streptococcus* sp., *Pseudomonas* sp., and *Edwardsiella tarda* were occasionally associated with the ulcers (Supamart *et al.* 1983). In a rare case, about 1.0% of cage-cultured sand goby in Nakornsawan Province developed a tumor after stocking for four months (Limsuwan and Chinabut 1984). The cause of this tumor has not been determined.

Striped catfish (*Pangasius sutchi)* is also one of the species being successfully cultured in ponds and cages. However, it has not suffered as many disease problems as have snakehead, walking catfish, and sand goby, despite a similar culture system. During the outbreak of epizootic ulcerative syndrome, infected snakehead and walking catfish suffered high losses but striped catfish reared in the adjacent ponds were free of disease. Although a number of parasites were found, no pathology was noted. *Ichthyophthirius multifiliis* and *Trichodina* sp. were the only protozoa frequently found on striped catfish (Tonguthai 1967, Pawaputanon and Chinabut 1983). *Ichthyophthirius* was commonly observed on fry rather than on adults. In 1984, at Chiengmai Fisheries Station, this parasite entirely wiped out one batch of striped catfish fry. Trichodiniasis also causes a similar problem for fry. Ulcers were occasionally seen in adult fish but did not lead to mortality. Bacteria associated with the ulcers were mainly *A. hydrophila* (Tanasomwang and Saitanu 1979).

In Thailand, herbivorous fishes such as Javanese carp, Nile tilapia (*Oreochromis niloticus* (L.)), snakeskin gouramy, common carp (*Cyprinus carpio* L.), and Chinese carps do not seem to have many parasites or disease problems. *Aega* sp., an isopod parasite, is a blood feeder which occasionally infects Nile tilapia and snakeskin gouramy with severe impact (Tonguthai 1968). It was observed that *Aega* sp. can kill tilapia of 3-5 cm length within five minutes. *Ichthyophthirius multifiliis* was found more often than other protozoa and causes mortalities of fry. *Ichthyobodo* infection can increase mortality of fish during transportation. During 1981-1985, snakeskin gouramy was also one of the major species affected by severe epizootic ulcerative syndrome in Thailand. Mortalities were not as great as in snakehead, but were the most severe problems in this fish's culture history.

Seabass and grouper are the most economically important species for brackishwater culture. At present, cage culture of these two species increases so rapidly that these culture systems may succumb to disease problems. Protozoa are a major cause of fry mortality, especially at the age of 10-20 days (Ruangpan 1985). *Ichthyophthirius multifiliis* is widespread in freshwater seabass culture (Kesornchandra and Boonyaratpalin 1984). *Cryptocaryon* is the most common protozoan of seabass fry in brackishwater culture (Direkbusarakam and Pongmaneerat 1984). *Trichodina* is often associated with fish cultured in cages under crowded conditions. In heavy infections, mortality of up to 50% was observed (Ruangpan 1985). *Caligus* and *Ergasilus*, two genera of parasitic copepods, may cause problems in brackishwater culture. High intensities of infection by *Ergasilus* can cause a significant area of the gills to become non-functional. A report from Songkhla Fisheries Station noted that all seabass cultured in cages at the station were killed by *Caligus*, which infected the skin and the inner surface of the opercula. During the rainy season, when salinities are low, the isopod *Aega* sp. has also caused the same problems as those previously mentioned for Nile tilapia and Javanese carp (Ruangpan 1985).

Lymphocystis was first reported from seabass in cage culture from Songkhla Lake in 1983 (Limsuwan *et al.* 1983). Approximately 70% of the fish sampled were infected. The disease remained on the fish for about three months, causing only 1% mortality.

Bacteria commonly reported from seabass are *Vibrio parahaemolyticus, Aeromonas hydrophila,* and *Flexibacter columnaris* (Kesornchan and Boonyaratpalin 1984). An outbreak of columnaris disease occurred in seabass cultured in cages in Songkhla Lake during December 1983 to January 1984. External lesions advanced to cause fin rot, scales fell off, and brown-colored ulcers appeared (Donyadon *et al.* 1984).

Conclusions

Aquaculture in Thailand involves intensive culture systems with high stocking densities. Proper management is essential, otherwise disease problems will continue. Fish farmers realize this and attempts are being made to improve water quality through applying aeration and the use of pelleted food.

The 1981-1985 outbreaks of epizootic ulcerative syndrome caused dramatic losses of cultured fishes and exerted a great effect on the fishery economy of Thailand. Such a large scale epizootic had never previously occurred. Although an exotic origin for this disease has not been conclusively shown, the importation of live fish may provide an avenue for pathogen transmission. Therefore, emphasis should be placed not only on identifying pathogenic organisms but also on developing quarantine and fish health certification systems for Thailand.

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Session II Summary

CURRENT STATUS OF PROGRAMS FOR FISH HEALTH CERTIFICATION AND QUARANTINE SYSTEMS

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Southeast Asia is the world's main source of aquaculture products of both food and ornamental fishes. With the rapidly increasing demand for aquaculture products, the industry has been undergoing changes into intensive culture systems. Although the role of disease has been underestimated in terms of economic losses to aquaculture, it is now generally recognized that disease represents a major threat to successful fish culture. In addition, the increase in the traffic of live fishes, both internationally and within countries, has caused considerable concern, as it has further compounded the disease problem. Research findings have shown that many of the fish pathogens that cause sporadic mortalities or serious epizootics were previously unknown to the region and were introduced along with exotic fish species.

Several of the countries with interest in aquaculture are concerned about fish diseases and several practise some form of quarantine or have certification procedures for live fishes, while others are in the process of adopting such measures. The following is a summary of the status of quarantine and certification procedures being adopted by the various countries represented at this meeting.

Thailand

Legislation for quarantine and certification procedures does not exist as yet. However, certificates of health are being issued to exporters which are based only on visual inspection of fish for signs of gross pathology and microscopic examination for ectoparasites. Treatment is recommended if fish are found to be infected. The Department of Fisheries has recently received IDRC support for the training of diagnostics personnel and purchase of equipment for virology.

Malaysia

After having experienced the 1981-1982 outbreak of epizootic ulcerative syndrome, the government has now given priority to the establishment of fish quarantine stations and a quarantine system. Five quarantine stations will be established as part of the next Five Year Plan, beginning in 1986.

Sri Lanka

At present, there is no legislation governing export/import and quarantine of fishes. However, the Ministry of Animal Production and Health requires that the importer provide a satisfactory health certificate from the country of origin, certifying that the fish are free of disease. Upon arrival, the fish are released immediately to the importer. No holding or disease screening procedures are undertaken at present. A fish disease unit is being initiated and will look into the formation of quarantine and certification procedures.

Philippines

Fish quarantine and certification policies were incorporated into the Fisheries Administration orders of 1981 and 1983, respectively. However, their implementation has not been based on scientifically accepted procedures. Fish are only given visual examination to certify good health.

The Bureau of Fisheries and Aquatic Resources conducts all administrative activities pertaining to quarantine and certification.

Indonesia

In 1974 six main ports were identified for quarantine stations and to date 140 personnel have been trained to facilitate the quarantine system.

Since equipment for examination of fishes is still lacking at these stations, the services of the Veterinary Department are sought wherever possible.

Fish quarantine procedure is now a regulation which was promulgated on May 6, 1986. The regulation states that all fishes to be imported require a permit from the Ministry of Agriculture and should be accompanied by a health certificate from the country of origin. All imported fishes must be quarantined for one month.

A national institute for quarantine and certification is now being planned and will coordinate all quarantine activities.

Overview

Current regulations governing fish quarantine and certification are still rather vague, resulting in poor implementation. None of the countries that have implemented quarantine and certification measures have drawn up a schedule of notifiable diseases, although such a list should be considered a necessity, even before the regulations are implemented. Quarantine examinations based only on visual examination are not effective in detecting pathogens associated with fish that are leaving or entering a country. These factors have resulted in ineffectiveness of the whole exercise. Certificates issued to the exporters of fish are now merely looked upon as a permit or licence of export rather than as a document of declaration that fish meant for export are actually free of disease causing agents.

The following are additional reasons that have been put forward as causes for the ineffectiveness of the implementation of quarantine and certification procedures in South and Southeast Asia:

1. Lack of personnel qualified to inspect fish consignments to be imported or exported and to conduct diagnostic procedures.

2. Insufficient baseline research and lack of detailed knowledge on the disease causing agents.
3. Limited funds for the establishment of quarantine stations, salaries, the purchase of equipment, training of personnel, and for research.
4. Lack of implementation of standardized systematic procedures for the examination and certification of fish.
5. Lack of cooperation among various government departments which could provide input towards quarantine and certification procedures e.g., veterinary departments often have laboratory facilities for parasitology, microbiology, and pathology which could be easily used by the fisheries departments. Even the veterinary staff could be requested to assist with routine diagnosis.
6. Lack of publicity and public knowledge of the effects of fish mortalities, disease, and subclinical infections and the monetary losses they cause.
7. Lack of planning and coordination for the implementation of quarantine and certification procedures among South and Southeast Asian countries.

The general consensus is that the following requirements need to be met at the regional and national levels to strengthen and streamline the existing framework of quarantine and certification. Additionally, these measures will benefit member countries that are still in the process of establishing quarantine and certification procedures.

Requirements at a regional level:

1. Establishment of a technical committee which will be comprised of at least two representatives of all South and Southeast Asian countries. The members should be qualified personnel who will be directly involved in the implementation procedures. The main objectives of the committee will be to standardize all procedures for examination of live fishes and the issuance of certificates and to draw up a schedule of notifiable diseases.
2. Establishment of a reference centre where researchers could submit their material for diagnosis in case of doubt.
3. Establishment of a regular fish health newsletter which will provide up-to-date information on problems and advances for the region.
4. Establishment of an information retrieval and collection centre specialized for fish health.
5. Regular training of specialists on advanced techniques pertaining to pathogens, disease treatment, and other matters relating to fish health and quarantine.

Requirements at a national level:

1. Establishment of a technical committee whose main task would be to draw up guidelines for each country on operational procedures and to coordinate all activities relating to quarantine and certification. This committee should

include representatives from the Department of Fisheries, research institutes involved in fish diseases, and other relevant authorities/departments (e.g., veterinary departments) who would be directly involved in the exercise.

Other tasks of the committee would be as follows:

i. Monitor and assess all ongoing national and international activities in fish health.

ii. Establish and maintain an inventory of fish pathogens and disease causing factors.

iii. Work towards the eradication of existing serious pathogens.

iv. Provide a liaison for the national government with the regional technical committee; and

v. Arrange training for extension officers and personnel involved in quarantine and certification procedures.

Implementation of quarantine and certification procedures:

Quarantine and certification procedures should be studied in detail before they are implemented. This is to ensure that they will benefit the aquaculture industry in the long term, rather than be a limiting factor. Lengthy bureaucratic procedures will deter the importers, exporters, and fish farmers from providing the cooperation which is essential to effective quarantine and certification programs. The procedures should be presented as preventive and control measures to check fish pathogens, a policy which will assist in the development of an economically viable and healthy aquaculture industry.

The guideline provided below is an ideal scheme; some countries are already working on these principles. It should be possible to implement the system at an early date in those countries which have the required facilities. Those countries which are in the process of developing the technical capability and have yet to initiate a quarantine system could adopt procedures similar to this guideline. As technical abilities improve quarantine and certification can be extended to provide specific notifiable disease-free status for fish to be exported or imported.

Exporter/Importer	**Quarantine and certification authority**
Registered fish farm	Regular examination and monitoring for bacteriology; virology and mycology examination of the liver, kidney and spleen and a full parasitological examination at 3 (?) monthly intervals
Will record and inform authorities of any serious mortality	
Consignment to be exported	Issue certificate of origin and health stating that the fish come from a farm that has been free of serious epizootic for the last calendar year
Provide dip treatment at farm to remove ectoparasites	This certificate should also provide details of treatment
Arrival at importing country	The certificate of origin and health accompanying the consignment must be examined and approved
Remaining consignment introduced into "restricted ponds" at the farm	Statisticaly valid sample removed for examination and observation over a 2 week period
Fish could be released into ponds or sold after receiving clearance certificate	Provide clearance certificate that fish are free of pathogens

Concluding remarks:

This is not the first time that the areas of quarantine and fish health have been discussed at a regional level. Two previous meetings were held in Indonesia in 1978 and 1982, where scientists discussed many of the points raised at this meeting. We need to ask ourselves "Why has there been so little progress in the development and implementation of fish quarantine systems within the region?" As scientists we can contribute our expertise to such meetings, but ultimately any progress in the development of fish quarantine will depend on recognition and acceptance by the national policy makers of individual governments. Perhaps we need to put more pressure on the government departments responsible. To do this effectively, we have to have all the necessary information to convince the authorities of the necessity of these programs. As the group responsible for disease research, we need to apply ourselves to the task of obtaining this information.

It cannot be denied that the progress made so far has mainly been due to the contributions made by donor agencies. In view of the present economic downturn in the region, it is now imperative that the donor agencies play a larger role to help us achieve these aims.

CURRENT STATUS OF PROGRAMS FOR FISH HEALTH CERTIFICATION AND QUARANTINE IN INDONESIA

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Fish farming in Indonesia has been widely promoted, particularly through national intensification of aquaculture programs for both freshwater and brackishwater pond culture. Intensification of freshwater fish culture by means of running water systems is widely practiced. Prawn culture is also now being intensified as a lucrative enterprise for the export market. As a consequence, traffic of live fish both between the islands within Indonesia and between Indonesia and other nations has increased. Uncontrolled entry of live fishes into countries has often resulted in the transfer of parasites and microorganisms causing diseases of fish.

Disease is one of the factors which usually reduces fish production. The problem of fish diseases in Indonesia is, at present, confined only to ornamental and freshwater fishes. Several outbreaks of disease have been reported from various regions of the country. Parasites, such as *Ichthyophthirius multifiliis* Fouquet, 1876; *Lernaea cyprinacea* L.; and *Myxobolus* sp. have caused great losses to fry production. A newly reported disease, "epizootic ulcerative syndrome", has caused heavy mortalities of common carp (*Cyprinus carpio* L.), walking catfish (*Clarias batrachus* L.), snakehead (*Ophicephalus striatus* Bloch), and kissing gouramy (*Helostoma temmincki* Cuvier and Valenciennes) since 1980 in West Java.

This paper reviews existing quarantine procedures implemented in Indonesia and the program for fish health certification. Diseases of economically important fishes are also discussed.

Fish quarantine

Fish quarantine procedures are now regulated by Ministry of Agriculture Decree No. 265/Kpts/LB. 730/5/1986, which was promulgated on May 6, 1986. A fish quarantine system for Indonesia has recently been implemented with the establishment of an Agriculture Quarantine Centre covering plants, animals, and fishes. In 1974, the Directorate General of Fisheries (DGF) developed a fish quarantine service at six main ports located in Jakarta, Medan, Denpasar, Pontianak, Jambi, and Palembang. Only three of these, Jakarta, Medan, and Pontianak, are still functioning as ports of entry. To facilitate the stations, about 140 staff from the provincial fisheries services and research institutes have attended a two to three month fish quarantine training course given since 1976 at Ciawi Bogor. Training was made through the cooperation of DGF, the Agency for Agricultural Education Training and Extension (AAETE), the Research Institute for Freshwater Fisheries (RIFF), and Bogor Agricultural University (BAU).

Three personnel were trained abroad in practical fish disease diagnosis and immunology through funding from the International Development Research Centre (IDRC) to the Fish Parasites (Indonesia) project.

A manual for fish quarantine, a technical manual on fish transportation, and a manual of guidelines on fish health inspection have been published and circulated. These serve as guidelines for quarantine officers at the fish quarantine stations throughout the country.

The importation of live fish requires a permit from the Ministry of Agriculture. All live fish must be accompanied by a health certificate issued by the country of origin. All fish must be quarantined during inspection. According to Ministry Decree No. 265/Kpts/LB.730/5/1986 fish must be quarantined for not more than one month. If dangerous (prohibited) fish species are found in the consignment, they must be seized as government property or used for research purposes. In cases where fish are suffering from communicable disease, they must be treated before being released. If the disease is impossible to treat effectively, they must be destroyed.

Samples are taken from each shipment. The number of fish in each sample depends upon the species, their value, and total number of fish in the shipment. When inexpensive species are involved 10 to 20 fish of each species are taken per shipment; when more expensive fishes are involved fewer can be taken. Some fish are sent to the Research Institute for Freshwater Fisheries (RIFF) for disease diagnosis.

Fish diseases in Indonesia

The occurence of fish diseases in Indonesia was first reported by Sachlan (1952, 1974). The parasites *Ichthyophthirius multifiliis*, *Trichodina* sp., *Gyrodactylus* sp., *Dactylogyrus* sp., *Lernaea cyprinacea*, *Myxobolus* sp., *Ergasilus* sp., and *Argulus* sp. commonly infected fry. Other parasites were also identified.

Myxobolus sp. and *Myxosoma* sp. are major problems to overcome, as no chemicals nor drugs can be used to eradicate them from infected fishes. These parasites have caused mortalities as high as 60-90% (Djajadiredja *et al.* 1983). Prevention can be done by liming the pond with 200 g/m^2 and strengthening the fry with high quality feed.

Diseases caused by bacteria have caused great mortalities. Outbreaks involving *Aeromonas hydrophila* occurred in late 1980 (IFFRI 1980; Djajadiredja and Koesoemadinata 1982). Other bacteria (*Pseudomonas fluorescens*, *Vibrio anguillarum*, *Flexibacter columnaris*, *Mycobacterium* sp., and *Enterobacter*) have also been identified as causative agents of disease.

Two species of fungi, i.e. *Saprolegnia* sp., and *Achlya* sp., cause problems, especially in hatcheries.

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FISH QUARANTINE AND CERTIFICATION IN MALAYSIA

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Aquaculture is a fast expanding industry in Malaysia. In 1985 the total number of ponds developed for aquaculture was 17,905, with an area of 3,417 m^2. The number of culture cages has increased from 5,182 cages covering an area of 43,959 m^2 in 1983 to 6,835 cages covering an area of 82,339 m^2 in 1985. In 1985 the number of cages in freshwater was 1,354, covering an area of 21,208 m^2 compared to 5,481 cages with an area of 61,131 m^2 in brackishwater. The species of fishes commonly produced are bighead carp (*Aristichthys nobilis* (Richardson)), common carp (*Cyprinus carpio* L.), grass carp (*Ctenopharyngodon idella* (Cuvier and Valenciennes)), and Javanese carp or tawes *(Puntius gonionotus* (Bleeker)).

Most bighead carp and grass carp fingerlings are imported into Malaysia. In 1985, ten million food fish fry worth $1,847,820 Malaysian ringitt (MR) and nine million ornamental fishes worth MR$4.7 million were imported.

In 1985, Universiti Pertanian Malaysia (UPM) with the aid of the International Development Research Centre (IDRC) carried out a Phase II project on fish parasites of Malaysia. This study was conducted to look at the parasites and pathogens of imported fry. The detailed findings of this study were presented at the "Symposium on Practical Measures for Preventing and Controlling Fish Diseases" at Bogor, Indonesia (Shaharom 1985).

This study was based on the examination of fry from two fish importers in Malaysia, the South East Asian Farm in Enggor, Perak; and Ban Lee and Company, Salak South, Selangor. The former provides fry to the breeding stations and fish farmers of northern Malaysia while the latter provides fry to those in the south.

The most common parasites of bighead carp and grass carp have been described by Shaharom (1985). The oviparous monogeneans *Dactylogyrus nobilis* Long and Yu, 1958 and *D. aristichthys* Long and Yu, 1958 are seen on the gills of bighead carp. Two species of peritrichs were found on bighead carp, *Trichodina nobilis* Chen, 1963 and *Trichodinella minuta* (Chen, 1957). Numerous suctorians are also seen, especially *Trichophyra.* The holotrichous ciliate *Ichthyophthirius multifiliis* Fouquet, 1876 and the viviparous monogenean *Gyrodactylus* were also observed. The flagellated protozoans *Ichthyobodo* and *Piscinoodinium* also occurred on the gills. The crustacean parasites *Lernaea* and *Argulus* were present occasionally. Adults of the digenean *Sanguinicola armata* Plehn, 1905 were located in the gills, within the caudal blood vessel, and in the bulbus arteriosus of the heart.

Similar parasites are also seen on grass carp except that the monogeneans are *D. lamellatus* Akhmerov, 1952 and *D. ctenopharyngodonis* Akhmerov, 1952. Another parasite, found only in the gall bladder of grass carp, is the myxosporidan *Chloromyxym legeri* Touraine, 1932. *Sanguinicola armata* was also found in the bulbus arteriosus. *Sanguinicola* has not yet been found in any native fish of Malaysia. This study is important in that it provides an index of the parasites entering the country through the importation of exotic fishes.

In Malaysia, the only fish disease epizootic so far reported is the outbreak of epizootic ulcerative syndrome of late 1981 to early 1982, where fish had large red or necrotic areas of ulceration over their bodies. Thousands of fish in submerged cages in Kuala Muda and Langkawi died. The investigating team, comprised of scientists from the Fishery Department and local universities, was of the opinion that toxic substances from pesticides were the cause (Anon. 1984). So far no mortalities have been traced to imported fishes.

At present, there is no quarantine policy for the importation of live fishes. Therefore, the aquaculture industry in Malaysia is exposed to the dangers of foreign pathogens. Table 1 shows the number of imported and exported live fish fry and ornamental fishes from 1978 to 1980 according to country of origin and destination. Table 2 shows the total number of imported and exported live fish fry and aquarium fishes from 1981 to 1985. The sites of entry are Johor, Penang, Subang, and Changlun in Kedah. The importation of fry is necessary in order to keep up with the expansion of the aquaculture industry. In 1985, the demand was 96.5 million fry compared to only 15 million in 1981. Local fry production is still limited. The Fishery Department could only produce 11.4 million fry in 1981, however this increased to 39.5 million fry in 1985.

Quarantine feasibility study

In 1983, a feasibility study was initially carried out by the Fishery Department with the aid of the IDRC. Prof. R.J. Roberts, a consultant from the University of Stirling, was sent to study the feasibility of establishing a quarantine system for fisheries in Malaysia. As a result of his visits to various institutions and the fish and prawn ponds, he submitted a report entitled "Feasibility of Setting up a Fish Quarantine and Health Certification System in Malaysia". According to this report, the quarantine system could be implemented in three stages:

a) Establishment of a "Centre of Excellence";

b) Establishment of Diagnostic Centres; and

c) Establishment of Quarantine Centres.

The "Centre of Excellence" would be responsible for carrying out research on fish diseases in Malaysia, including both basic and applied research. Basic research is carried out at the universities, while the applied research will be carried out by the Fisheries Research Institutions at Glugor and Batu Berendam.

The Diagnostic Centres would carry out diagnosis of fish diseases and analyze water samples brought in for testing. Each centre would service several nearby fish growing areas.

The Quarantine Centres would be the place where newly arrived fishes which have been imported will be kept for a period, so the inspectors from the Fishery Department can examine them for pathogens.

A technical committee was set up which includes officers from the Fishery Department and representatives from the UPM. The committee gave guidelines on the operations, methodology, training, infrastructure, and costs involved in the study. At present, the guidelines are being studied by the Fishery Department.

Table 1. Imports and exports in live fish fry and ornamental fishes by countries of origin and destination

		IMPORTS			EXPORTS		
Year	Category	Country of Origin	Quantity	Value MR$	Country of Destination	Quantity	Value MR$
1978	Fry	Singapore	94,280	7,784	Singapore	5,000	1,200
		Thailand	408,170	40,407	Hong Kong	2,850	400
		Indonesia	69,980	5,933	Others	63,000	7,815
		Japan	94,160	6,630			
		Hong Kong	528,980	43,945			
		Taiwan	667,310	59,055			
	Total		1,858,880	163,754		708,500	9,415
	Aquarium fish	Singapore	1,093,905	177,397	Singapore	5,163,391	211,059
		Thailand	101,680	14,814	Thailand	8,600	181
		Indonesia	37,000	2,329	Japan	3,000	200
		Japan	5,670	10,196	U.K.	35,141	11,415
		Hong Kong	1,014,624	56,804	Hong Kong	18,300	1,189
		Taiwan	94,900	27,210	Others	453,913	7,367
		Others	547	1,402			
	Total		2,348,326	290,152		5,682,345	231,407
1979	Fry	Singapore	618,410	62,738	Singapore	3,553	3,086
		Thailand	148,990	10,494	Hong Kong	120	315
		Indonesia	39,680	2,381	Taiwan	2,700	142
		Hong Kong	324,080	31,511	Others	10,277	39,916
		Taiwan	519,890	41,410			
		China	10,000	7,499			
		Others	182,150	6,328			
	Total		1,843,200	162,361		141,120	43,459
	Aquarium fish	Singapore	1,663,469	334,191	Singapore	9,329,292	197,781
		Thailand	404,076	48,570	Thailand	6,100	121
		Hong Kong	261,550	108,805	U.K.	23,954	5,876
		Taiwan	32,221	3,322	Taiwan	1,450	290
		China	83,727	6,447	Others	51,600	11,958
		Others	101	912			
	Total		2,449,413	503,241		9,412,396	216,026
1980	Fry	Singapore	801,040	101,621	Singapore	18,030	2,037
		Thailand	216,040	7,686	Hong Kong	2,000	200
		Indonesia	480	848	Others	17,760	4,575
		Hong Kong	2,943,940	109,460			
		Others	460	1,877			
	Total		4,788,200	273,458		37,790	6,806
	Aquarium fish	Singapore	1,962,526	397,448	Singapore	3,931,658	184,681
		Thailand	768,640	167,773	Thailand	2,060	137
		Japan	10,630	6,055	Japan	6,500	1,375
		Hong Kong	143,166	67,085	U.K.	1,146	1,402
		Taiwan	13,449	6,585	Hong Kong	434,480	3,064
		China	1,000	1,743	Taiwan	3,650	193
		Others	302,529	121,366	Others	37,879	21,253
	Total		3,197,975	768,055		4,417,373	212,105

Table 2. Numbers of imported and exported fry and ornamental fishes for Peninsular Malaysia from 1981-1985

		IMPORTS		EXPORTS	
Year	**Category**	**Quantity**	**Value (MR$)**	**Quantity**	**Value (MR$)**
1981	Fry	1,579,230	484,543	43,690	11,600
	Aquarium fish	9,410,522	1,200,894	4,116,245	247,471
1982	Fry	4,704,610	737,462	171,860	54,128
	Aquarium fish	9,812,981	2,227,307	3,218,540	433,766
1983	Fry	7,957,350	669,214	170,146	69,650
	Aquarium fish	7,031,876	2,513,612	4,765,674	876,391
1984	Fry	7,960,070	1,085,637	553,340	112,134
	Aquarium fish	9,493,788	4,078,730	27,399,780	376,637
1985	Fry	9,891,810	1,847,820	1,329,920	155,565
	Aquarium fish	9,308,215	4,707,098	5,335,417	356,086

Training of fishery officers, to be carried out at the UPM, will equip the officers with knowledge on disease agents, quarantine procedures, and methods of diagnosis and treatment of disease.

To achieve an efficient quarantine system for fish diseases, the role of the Quarantine Centre has to be emphasized. This involves legislative procedures and at the present moment it cannot be implemented because a detailed study is necessary, especially with regard to legal procedures. Therefore technical aid with regard to this aspect is needed so that a program of quarantine and health certification of fish can be implemented in Malaysia.

Five Quarantine Stations will be established:

(i) Near Tambak Johor, Johor.
(ii) Rantau Panjang, Kelantan.
(iii) Bukit Kayu Hitam, Changloon, Kedah.
(iv) Near Bayan Lepas Airport, Penang.
(v) Near Subang Airport

The examination of imported and exported fishes will be carried out by fishery officers. Diseased fish will be removed for pathological examination while others will be sent to the quarantine centres for two weeks. At the quarantine stations they will be examined carefully and where possible, treatment carried out on diseased fish. If no disease is found and the pathological report is satisfactory, the fish can be released and a health certificate issued. Food, chemicals, and other expenses will be charged to the importer or exporter.

The Quarantine Centres will be equipped with facilities for carrying out studies in pathology, parasitology, bacteriology, and mycology. Virological studies will be carried out in the Veterinary Diagnostic laboratories or at the local universities.

The project has been scheduled to start in 1986, with the schedule of construction of the Quarantine Centres as follows:

A. Changloon, Kedah
October 1986-October 1987

B. Bayan Lepas, Penang
March 1986-March 1987

C. Subang, Selangor
March 1986-March 1987

D. Johor Bahru, Johor
October 1986-October 1987

E. Rantau Pangjang, Kelantan
March 1987-April 1988

It has been estimated that a total of MR$1,000,000 is needed to set up the five quarantine centers at a cost of MR$200,000 each. The breakdown of the estimated costs of construction is shown in Table 3. Estimated annual operating costs are given in Table 4.

Table 3. Estimated costs for infrastructure and management of each of five quarantine centers. (In MR$)

Item	Cost
Purchase of 2 acres of land	$50,000
Building construction	120,000
Equipment	30,000
Total	$200,000

Table 4. Estimated annual operating costs for each quarantine center (In MR$)

Item	Cost
Salaries and allowances	$30,000
Aeration and electricity	3,000
Chemicals	5,000
Oil	2,000
Travel	10,000
Total	$50,000

Benefits and justification of the project

The control and quarantine of fish is necessary for the prevention of disease to protect the local fishing and aquaculture industries, and also the food export industry. This control will also protect local native fishes. Presently, Malaysia does not have any form of quarantine system. Hence there is no way to prevent foreign pathogens from entering the country. With a quarantine and health certification system, Malaysia will not only prohibit the entry of foreign fish pathogens but will also be able to ensure that its own fish exports are free of contagious diseases and that they will be highly accepted by overseas markets.

Acknowledgements

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REPORT ON PHILIPPINE FISH QUARANTINE AND CERTIFICATION PROGRAMS

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During the past decade, the development of aquaculture in the Philippines has made great progress. Annual fish production has increased dramatically, rising some 300%, from a volume of about 160,000 t in 1976 to almost 480,000 t in 1984 (BFAR unpubl. data). During this period, the relative contribution of aquaculture to the total fish production in the Philippines has more than doubled, increasing from 11.4% of the total in 1976 to 23% in 1984.

With the introduction of intensive fish farming practices in the early 1970s, the stocking of superior disease resistant strains became a major goal of the industry. With the exception of milkfish (*Chanos chanos* (Forskal)) and prawns (*Penaeus* spp.) all major species cultured in the Philippines are introduced. Hence, live fish importation for domestic aquaculture and stocking in natural waters has increased over the past several years. Although live fish importation greatly contributes to increased production, there is no assurance that imported fishes and invertebrates are free from parasites and diseases which might contaminate Philippine waters. This paper discusses the extent of live fish and shellfish importation and exportation in the Philippines, reviews current quarantine and certification regulations, and comments on the effectiveness of their implementation. Also discussed are the future needs and probable directions of the Philippine quarantine and certification program for aquatic organisms.

About five million live fishes and aquatic invertebrates were imported into the Philippines during the period 1980-1985, primarily from Taiwan, the USA, Thailand, Singapore, Japan, Hong Kong, Israel, and West Germany (BFAR unpubl. data). Prawn fry and breeders, mostly giant tiger prawn (*Penaeus monodon* (Fabricus)) and Indian prawn (*P. indicus* (H. Milne Edwards)), topped the list of all live imports, accounting for 33.4% of the total number. Most of these prawns originated from Panama, Hawaii, Guam, Israel, the United Kingdom, and South Korea. Second in numbers was giant freshwater prawn (*Macrobrachium rosenbergi* (de Mans)) fry and breeders, comprising about 21% of the total, followed by common carp (*Cyprinus carpio* L.) and silver seabass (*Lates calcarifer* (Bloch)), contributing 20.5% and 14.7% of the total, respectively. Other species imported during this period include Nile tilapia (*Oreochromis niloticus* (L.)) (4.2%), various marine aquarium fishes (3.6%), and channel catfish (*Ictalurus punctatus* (Rafinesque)) (2.6%). No estimates of the values of these fishes are available.

Live fish exportation from 1980-1985 constituted several million marine aquarium fishes and about 85,000 prawn fry and breeders, which were exported to Tahiti, Guam, the United Kingdom, and Israel. Most of these were giant tiger prawn and Indian prawn. Commercial values are not available.

An effective quarantine and certification program is the key to preventing and controlling exotic aquatic parasites and diseases. Quarantine refers to a period of isolation of newly transported fishes and aquatic invertebrates until the possibility of introducing any pathogens they may carry can be eliminated (Kabata 1985). Certification may involve either certification of the source of origin (preferred) or certification of individual lots. Certification at origin ensures that the facilities from which fish or other aquatic organisms originate are free of specified diseases. Certification of lots certifies that a given shipment of fish or other aquatic organisms has been inspected, either by the exporting or the importing country, and found free from specified pathogens. Both quarantine and certification should be based on recognized examination techniques for specified pathogens (see, for example, McDaniel 1979, Department of Fisheries and Oceans 1984) and require examination of sample sizes sufficient to detect a minimum predetermined carrier prevalence with a predetermined degree of statistical confidence. A thorough review of existing Philippine quarantine and certification regulations and related implementation activities is an initial step towards formulating more responsive and sound government policies on these matters.

Definition of acronyms

- ASEAN — Association of Southeast Asian Nations
- BFAR — Bureau of Fisheries and Aquatic Resources. BFAR is the sole Philippine governmental agency charged with formulating and implementing national policies involving fisheries and aquatic resources.
- FAO — Fisheries Administrative Order. An FAO is an official document pertaining to rules and regulations regarding all fishery and aquatic resources in the country. It is duly endorsed by the BFAR Director and approved by the Minister of Agriculture and Food.
- FQS — Fish Quarantine Service. This service unit of the BFAR is charged with inspecting all imported and exported fishery and aquatic products.
- MIA — Manila International Airport. MIA, the major international airport in the Philippines, is where the FQS is located.

Review of fish introductions

The first recorded fish introduction in the Philippines was in 1907 when largemouth bass (*Micropterus salmoides* (Lacépède)) were imported from the USA for sportfishing purposes (Welcomme 1981). Although this introduction failed, later transplants have established a breeding population of bass at Caliraya Lake, Laguna Province. Common carp were first introduced in 1910 from China and were successfully propagated. Although now widely distributed in natural waters, it is not extensively cultured. The first tilapia to be introduced was the Mossambique tilapia (*Oreochromis mossambicus* (Peters)), imported in 1950 from Thailand. This species reproduced rapidly and is now found in both fresh and brackish water throughout the country. Other exotic fishes introduced between 1907-1969 include mosquito fish (*Gambusia affinis* (Baird and Girard)) and top minnow (*Poecilia latipinna* (Lesueur)), both introduced from Hawaii in 1913 and 1914, respectively; giant gouramy (*Osphronemus gouramy* Lacépède), introduced in 1927 from Indonesia, white catfish (*Ictalurus catus* (L.)), imported in

1935 from California; snakeskin gouramy (*Trichogaster pectoralis* (Regan)), three-spot gouramy (*T. trichopterus* (Pallas)), and pearl plasalid (*T. leeri* Bleeker), all introduced in 1938 from Thailand; loach (*Misgurnus anguillicaudatus* (Cantor)), introduced in 1942 from Japan; kissing gouramy (*Helostoma temmincki* (Cuvier and Valenciennes)), introduced in 1948 from Thailand; green sunfish (*Lepomis cyanellus* Rafinesque) and bluegill (*L. macrochirus* Rafinesque), both introduced in 1950 from the USA; tawes (*Puntius gonionotus* (Bleeker)), introduced in 1956 from Indonesia; nilem (*Osteochilus hasselti* Cuvier and Valenciennes) imported in 1957 from Indonesia; silver carp (*Hypophthalmichthys molitrix* (Valenciennes)), introduced in 1964 from Taiwan; mrigala (*Cirrhina mrigala* Hamilton-Buchanan), catla (*Catla catla* (Hamilton-Buchanan)), and rohu (*Labeo rohita* (Hamilton-Buchanan)), all introduced in 1964 from India; crucian carp (*Carassius carassius* (L.)), introduced from Japan in 1964; grass carp (*Ctenopharyngodon idella* (Cuvier and Valenciennes)), introduced from China in 1964; and bighead carp (*Aristichthys nobilis* (Richardson)), imported in 1968 from Taiwan. Also introduced during the 50's or 60's was red tilapia (*O. mossambicus* x *O. niloticus*), although the precise date of introduction and country of origin are unknown (Dr. R.G. Arce pers. comm.). Additionally, two non-piscine introductions occurred during the period 1907 to 1969. The giant East African snail (*Achatina fulica* Fer) was introduced in 1942 from Japan by occupying military forces and the bullfrog (*Rana catesbiana*) was imported in 1968 from Louisiana, USA.

Several major fish importations occurred during the 70's and 80's. In 1970 and 1973 Nile tilapia of Egyptian and Ugandan stocks were imported from Thailand and Israel, respectively. Zill's tilapia (*O. zilli* (Gervais)) was introduced in 1973 from Taiwan and *O. aureus* (Steindachner) was brought into the Philippines from Auburn, Alabama in 1977 (see Guerrero 1983), although an earlier introduction of this species (exact date and origin unknown) is reported (Dr. R.G. Arce pers. comm.). Imported in 1984 from Thailand was the walking catfish (*Clarias batrachus* (L.)). Channel catfish were first imported from Japan in 1980. However, no record of the stocking location is available. In 1983, silver seabass, a marine species enzootic to the Philippines, was imported from Thailand. In 1986, two additional species entered the country: mullet (*Mugil* sp.) from Taiwan and swamp eel (*Fluta alba*), from China, the latter species only being held for further shipment to Taiwan. Additionally, one invertebrate species was introduced during this period, the "kuhol", or golden apple snail (*Ampullaria* sp.) being imported from Florida in 1984.

With the early introductions and the more recent massive fish importations during the 1970's and 1980's, at least 30 species of exotic fishes, two molluscs, and one amphibian have been introduced into the Philippines. Several of these are now widely distributed in natural waters (e.g., *O. niloticus, O. mossambicus, C. carpio, C. batrachus*, and *T. pectoralis*). However, only a single exotic species, Nile tilapia, has become widely accepted for aquaculture purposes.

To date, little attention has been paid to the possibility that imported fishes and invertebrates could also be carrying exotic and potentially harmful diseases. In relation to this, recent findings by the BFAR Fish Health Project and other Philippine fish disease researchers indicate that many of the country's introduced fishes are infected with parasites which are previously unknown in the Philippines (see Table 1). Among these are a number of species of known pathogenicity (e.g., *Cichlidogyrus* spp.; *Procamallanus clarius* Ali, 1956; and *Bothriocephalus acheilognathi* Yamaguti, 1934). This situation is a great challenge to fish disease experts, as well as to national policy-makers, who must exert extra efforts to control and prevent the further spread of exotic pathogens, which clearly pose a serious threat to Philippine fisheries.

Table 1. List of exotic parasites which have become established in the Philippines

Species	Hosts	Records
Trichodina centrostrigata Basson, Van As & Paperna, 1983	*Oreochromis niloticus*	Natividad *et al.* 1986
T. heterodentata Duncan, 1977	*O. niloticus* *O. mossambicus* *Tilapia zilli* *Trichogaster trichopterus*	Natividad *et al.* 1986 Duncan 1977 " "
Trichodinella carpi Duncan, 1977[1]	*Cyprinus carpio*	Duncan 1977 J.R. Arthur unpubl.
T. tilapiae Duncan, 1977[2]	*T. zilli*	Duncan 1977
Cichlidogyrus sclerosis Paperna & Thurston, 1969	*O. mossambicus* *O. niloticus*	Duncan 1973 Natividad *et al.* 1986
C. longicornis longicornis Paperna & Thurston, 1969	*O. niloticus*	Natividad *et al.* 1986
C. tiberianus Paperna, 1960	*O. niloticus*	Natividad *et al.* 1986
C. tilapiae Paperna, 1960	*O. niloticus*	Natividad *et al.* 1986
Bothriocephalus acheilognathi Yamaguti, 1934	*Aristichthys nobilis* *Ctenopharyngodon idella* *Hypophthalmichthys molitrix*	C.C. Velasquez unpubl.
Procamallanus clarius Ali, 1956	*Clarias batrachus*	O. Quines unpubl.
Lernaea cyprinacea Linnaeus, 1758	*Chanos chanos*	Velasquez 1984 Regidor and Arthur 1986

[1]Probably a synonym of *T. epizootica* Sramek-Husek, 1953 (J.R. Arthur pers. comm.).
[2]Considered a synonym of *Tripartiella bulbosa* (Davis, 1947) by Shulman (1984).

Fish quarantine and certification policies

Quarantine, certification, and other related policies are incorporated in Fisheries Administrative Order No. 135, Series of 1981, entitled "Rules and Regulations Governing Importation of Fish/Aquatic Products" and FAO No. 147, Series of 1983, entitled "Rules and Regulations Governing the Issuance of Permits/Commodity Clearance for the Exportation of Fish and Fishery/Aquatic Products." These two FAO's are pursuant to the provisions of Sections 4 and 7 of Presidential Decree 704, dated December 1, 1976.

For ease of presentation, in the discussions that follow reference is made primarily to the quarantine and certification of fish stocks. It should be noted, however, that current Philippine importation and exportation regulations, and proposed plans for quarantine and certification programs pertain also to other living aquatic vertebrates, invertebrates, and plants.

Quarantine regulations

All regulations pertaining to live fish importation and inspection are provided in FAO No. 135. A duly accomplished Application for Importation shall be filed at the BFAR at least 30 days prior to the arrival of the shipment. One of the conditions contained in this application is that the consignee will provide BFAR samples of the fish for research purposes. Specifically, the second to the last paragraph of the application form states:

> "That the applicant shall provide BFAR sixty (60) live fish samples if the quantity of fish being imported exceeds six hundred (600) fishes. If the quantity of live fishes to be imported is less than six-hundred, then ten percent (10%) of the total quantity will be provided to BFAR. These live fish samples are solely intended for research purposes on fish parasites and diseases."

The same condition is also embodied in the Importation Permit to be issued by the BFAR Director. Importation of the fish shall be effected upon issuance of this permit.

Implementation

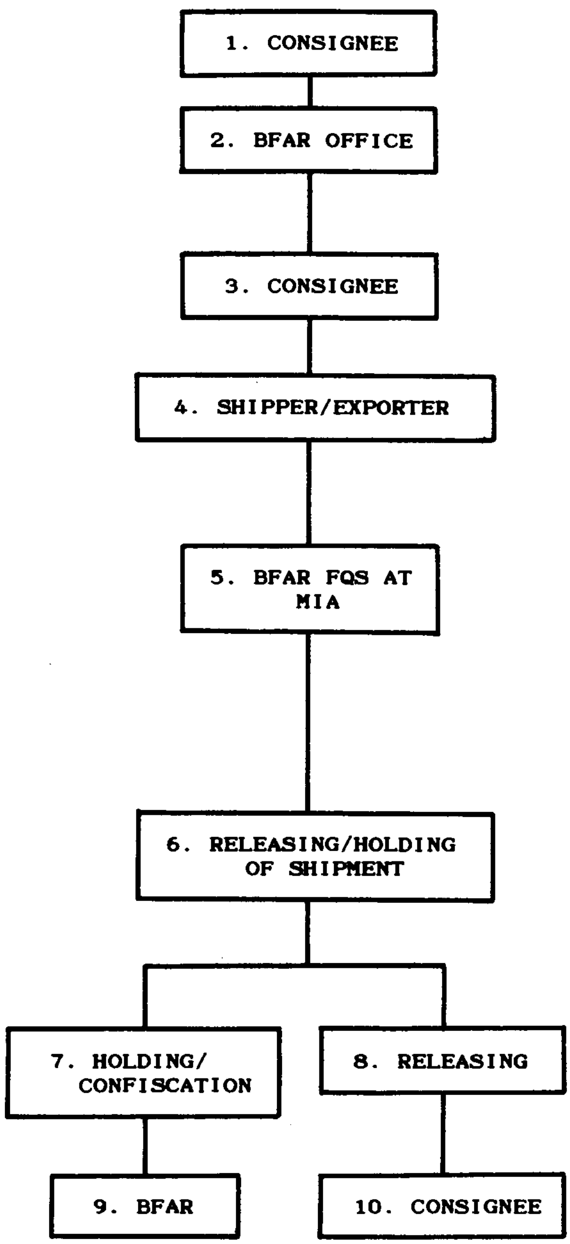
Application for importation of live fish will be approved by the BFAR Director upon presentation of a *pro forma* invoice, letter of intent, and an Article of Incorporation and By-Laws duly approved by the Securities and Exchange Commission. Individual applicants are exempted from the last requirement. Upon the issuance of the Importation Permit, the consignee will notify the shipper and eventually the BFAR Fish Quarantine Service Office as to the date, time, and flight number of the shipment.

Upon arrival, the Quarantine Officer will conduct a visual inspection of the shipment for parasites and diseases. This is in compliance with the provisions of FAO No. 135 Section 7, "Inspection of fish and fishery/aquatic products," which states that:

> "The fish and fishery/aquatic products shall be presented by the importer to the Director or to his duly authorized representatives upon arrival for inspection, quality control, prophylactic treatment, administrative and technical services as may be necessary. If, upon inspection, the fish or fishery/aquatic product does not meet the quality requirements prescribed by the Bureau or prohibited fish are included in the importation, the same shall be removed immediately and in the case of the latter, confiscated, and the importer shall, in addition, be penalized in accordance with the provisions of applicable laws, rules and regulations."

Simultaneous with inspection of the shipment, the BFAR Fish Health Project representative will obtain live fish as provided for in the Importation Permit for laboratory examinations at the BFAR's facilities in Quezon City. The data generated from this study will serve as baseline information for further policy formulation on live fish importation and quarantine.

After inspection, the Quarantine Officer will then prepare an Inspector's Report. Release of the shipment will depend upon his technical and administrative findings. Infected or diseased shipments will be put on "hold" or confiscated. On the other hand, the fish will be released to the consignee if they are healthy and disease-free. Confiscated fishes, whether infected, diseased, and/or illegally shipped will be turned over to the BFAR for destruction. Any illegal attempt to import fishes is punishable under the provisions of Section 10 of FAO No. 135. A schematic diagram, presented in Figure 1, details the flow of fish importation.



1. Files application for fish importation
2. Issues permit to import
3. Notifies shipper/exporter
4. Ships the live fish
5. Inspects/clears fish shipment:
   — Visual inspection of fish
   — Verifies/checks contents

   Administrative clearance of shipment by the BFAR FQS and Bureau of Customs

   Prepares Inspectors Report (FQS)

   BFAR Fish Health Project representative gets live fish samples for research
6. Fish shipment is released or put on hold and/or confiscated by the Quarantine Officer depending on technical and administrative findings
7. Fishes infected/diseased or illegally imported are put on hold and/or confiscated
8. Healthy and disease-free fish are released to consignee
9. Confiscated fishes are sent to BFAR for destruction or research
10. Released fish go to consignee

Figure 1. Schematic diagram showing the flow of live fish importation into the Philippines

Certification regulations

All regulations pertaining to live fish exportation are provided in FAO No. 147. The initial step is the completion of a Commercial Permit/Commodity Clearance at the BFAR office. Upon presentation of the required documents, the BFAR Director will then issue an Importation Permit to the applicant which will be valid for thirty days only from the date of issuance. All fishes which are due for exportation are subjected to inspection as per provision of Section 7 of FAO No. 147, entitled "Inspection, quality control and other administrative and technical services in the exportation of fish and fishery/aquatic products," which states that:

> "The fish and fishery/aquatic products including shells whether in raw, cleaned, semi-processed or finished state/form shall, before exportation, be presented by the exporter to the Director of Bureau of Fisheries and Aquatic Resources or his duly authorized representative for inspection, quality control and such other administrative and technical services as may be necessary, together with a copy of the Customs Export Entry, Exporter's Declaration and other required documents ..."
>
> "... If, upon inspection, the product sought to be exported does not meet the quality requirement prescribed by the BFAR, or prohibited fish or fishery/aquatic products are found included in the exportation, the same shall be removed immediately and, in case of the latter, confiscated, and the exporter shall, in addition, be penalized in accordance with the provisions of Section 8 of this Order."

Implementation

FAO No. 147 does not provide clear and specific rules as far as fish certification is concerned. Certificates of health are issued only at the request of the importing country. Hence, implementation typically involves only routine visual inspection to ensure that restricted species are not exported.

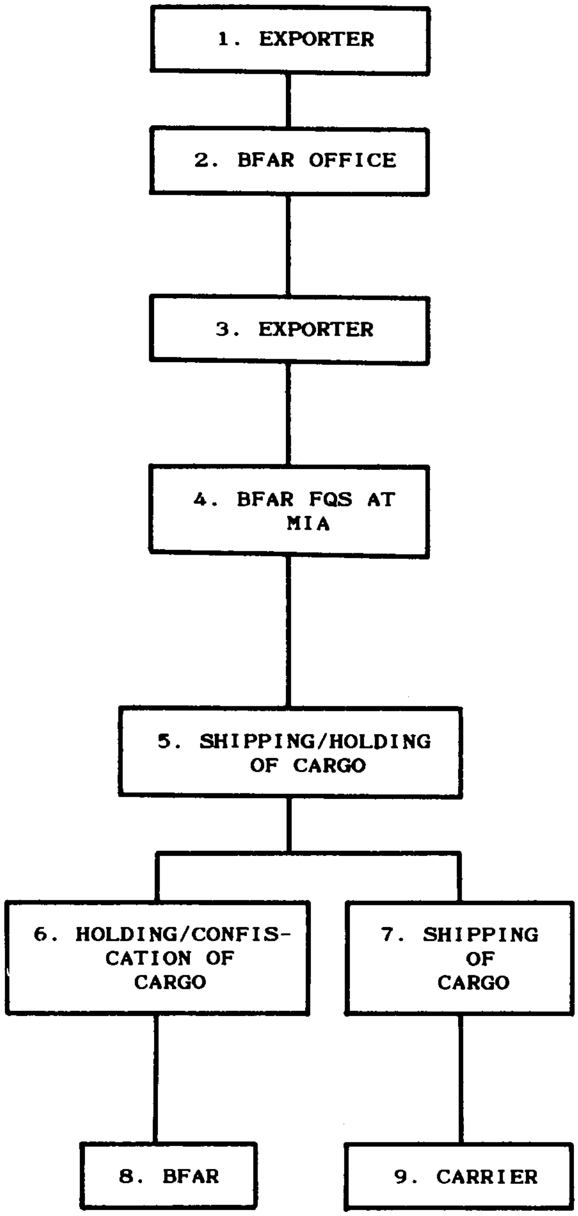
When the Commercial Permit/Commodity Clearance is issued to the importer, the BFAR Quarantine Officer will be notified as to the date, time, and flight number of the carrier. As soon as the fish arrive at the airport, they are subjected to visual inspection and administrative services are performed.

Fishes infected with parasites or diseases will be put on "hold" and/or confiscated by the Quarantine Officer. Healthy fishes will be allowed to be shipped to their destination. Any illegal attempt to export banned or prohibited fishes is punishable under the provisions of Section 8 of the same Order.

A schematic diagram, presented in Figure 2, details the flow of fish exportation activities.

Comments on the effectiveness of current quarantine and certification regulations

Fish quarantine and certification regulations are formulated to prevent potentially dangerous pathogens from entering and leaving the country. No



1. Files application for a Commercial Permit/ Commodity Clearance
2. Issues permit to export in the form of Commercial Permit/ Commodity Clearance signed by the BFAR Director
3. Notifies the BFAR as to actual date, time and flight number of carrier
4. Inspects/clears shipment
   — Visual inspection
   — Verifies/checks contents

   Administrative clearance by the BFAR and Bureau of Customs

   Live fish certificate is issued only if requred by country of destination
5. Fish shipment may be released or put on hold depending on findings of Quarantine Officer
6. Infected and/or diseased fishes are not allowed to leave the country
7. Healthy fishes are allowed to be shipped to country of destination
8. Confiscated fish go to BFAR for destruction or research
9. Healthy fishes go to carrier

Figure 2. Schematic diagram showing the flow of live fish exportation into the Philippines

amount of success can be achieved, no matter how well these regulations are formulated, unless they are supported by sound implementation guidelines and stringent enforcement. However, the Philippines has not yet developed a Manual of Implementation in order to effectively and scientifically implement existing regulations. In fact, existing regulations for fish quarantine and certification in the Philippines, as in many of ASEAN countries, are "weak." This situation is quite alarming, since most imported fishes originate from the ASEAN countries, such as Indonesia, Malaysia, Singapore, and Thailand. Most Philippine fishes are likewise exported to these countries.

In the Philippines, there exist policies for protecting and conserving fishery resources. However, there are no specific and clear-cut regulations for fish disease control through quarantine and certification. In the case of fish entering the Philippines, the Quarantine Officer performs only visual inspection. Likewise, only visual examinations are conducted on fishes due for exportation. In practice, quarantine is not applied. Certificates of health are not usually issued unless required by the importing country. Again, certification is a problem as far as the technical component is concerned. Fish can only be certified as being free from gross evidence of disease.

A closer examination of the provisions of FAO 135 and FAO 147 reveals some vagueness. Both regulations appear to be silent on fish quarantine and certification and merely speak of "inspection" and "quality control," terms which are relatively devoid of technical reference. In short, these regulations are technically impossible to implement since no implementing guidelines have been developed. For instance, it is impossible to declare that fish are healthy and/or disease-free without instituting scientifically accepted procedures for sampling and laboratory examination of shipments.

As an initial step, in April of 1985, the Philippine government entered into an agreement with the International Development Research Centre (IDRC) for the implementation of the BFAR-IDRC Fish Health Project. Its laboratory is currently being equipped with facilities for parasitology and bacteriology, and is manned by a capable staff whose technical skills are being further developed. This project conducts research on fish diseases and serves as a technical advisory group to the BFAR Director in policy formulation on fish diseases, fish quarantine and certification, and other related matters. Secondly, this project will render technical support to the BFAR FQS.

Future needs and recommendations

All regulations pertaining to the importation and exportation of live aquatic plants and animals should be reviewed and, if necessary, revised. Relative to this, there is an urgent need for an Implementation Manual which would detail the scientific procedures and methodology for implementing those regulations. In view of the need to review the current regulations on fish quarantine and certification in the Philippines, the following points are suggested for consideration:

- Because they are based on statistical probabilities, inspection procedures used for quarantine and certification can never be 100% effective. Thus, a major goal should be to reduce fish imports to the minimum necessary level, restrict imports of new species to the government only, encourage national breeding programs to achieve self-sufficiency in fry production, and, where possible, develop native (enzootic) fish species for aquaculture.

- Many diseases of cultured fishes have already been introduced into the Philippines. Hence, where feasible, a program should be implemented to contain or eradicate them.

- A committee should be formed with the mandate to review and approve or reject all requests to import exotic aquatic animals and plants. New introductions should not be made without serious consideration of the major and often irreversable ecological, socio-economic, and disease impacts which may result.

- A fish quarantine laboratory should be established at the MIA. This recommendation is a long term objective of the BFAR-IDRC Fish Health Project.

- Country and regional research to identify major diseases needing control and prevention should be strengthened. As an initial step towards formulating an Implementation Manual for fish quarantine and certification, country and regional (ASEAN) research to identify major fish diseases affecting each country should be implemented. These research activities will facilitate synchronization of fish quarantine and certification programs among the ASEAN nations. In the case of the Philippines, the BFAR-IDRC Fish Health Project is currently implementing some research projects addressed towards this goal (see BFAR 1984), namely:

  — Inventory of fish parasites and bacteria of selected species in fresh and brackish water aquaculture facilities;

  — Inventory of the parasites and bacteria of wild fishes in fresh and brackish water of the Philippines; and

  — Monitoring of parasites and diseases of imported fishes entering the Philippines for aquaculture purposes.

  The results being generated from these three research activities will serve as baseline information for future formulation and development of the Implementation Manual on Fish Quarantine and Certification in the Philippines.

- A workshop on standardizing fish quarantine and certification procedures in the ASEAN Region should be held. As most fishes imported and exported by ASEAN countries originate within the region it is imperative that ASEAN nations adopt mutually accepted quarantine and certification procedures.

Conclusions

With the continued intensification of aquaculture in the Philippines, importation of exotic fishes into the country is expected to escalate. In view of this situation, the Philippine government, through the BFAR, should give top priority to reviewing and updating its fish quarantine and certification policies in order to safeguard the aquaculture industry and native fish stocks from exotic diseases. A high level of cooperation among ASEAN nations is essential to minimize the threat posed by the international transfer of exotic pathogens. To assist in this endeavor, the Government of the Philippines should develop a reliable program for inspecting and certifying fish stocks for export.

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FISH QUARANTINE AND CERTIFICATION IN SRI LANKA

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The master plan for the development of fisheries in Sri Lanka calls for an increase in per capita fish consumption from the present level of around 15 kg/year to 21-22 kg/year by 1989. To meet this goal, it was estimated that the total fish production must be increased from 210,000 tons/year in 1982 to 330,000 tons/year by the year 1986 (Anon 1986a). The Maximum Sustainable Yield (MSY) of the continental shelf fishery of Sri Lanka is approximately 250,000 tons/year. The additional production required must therefore come from off-shore and deep-sea and/or the freshwater fisheries. As the cost involved in improving the off-shore and deep-sea fisheries is quite high, a significant proportion of the desired increase in production must therefore be generated by improving the freshwater fisheries. Since the 1970s, the Government of Sri Lanka has laid particular emphasis on the development of inland fisheries. The total fish production in 1985 was estimated as 186,536 tons and the contribution from the culture-based reservoir fisheries to this production was 19.3% i.e., 35,983 tons (Anon 1985).

The inland fishery of the island is based on extensive stocking in seasonal tanks and man-made reservoirs. There are over 108,480 ha of perennial irrigation reservoirs and 33,800 ha of seasonal water bodies in the country. Further, 120,000 ha of lagoons and estuaries form the brackishwater resources. In addition, considerable land suitable for pond construction may also be found, spread mostly in the country's wet zone (annual rainfall more than 190 mm). Utilization of these resources, through application of scientific methods to raise the level of productivity, is envisaged. The total annual fish production through the inland fisheries was projected to yield 50,000 tons by the year 1985 (Anon 1979).

To meet the projected production of freshwater fishes, the Sri Lankan government has embarked upon an immense aquaculture program in collaboration with various aid agencies, such as the Food and Agriculture Organization (FAO), the United Nations Development Programme (UNDP), the International Development Research Centre (IDRC), and the Asian Development Bank (ADB), involving millions of dollars. Experience has shown that intensification of aquaculture creates management problems, including outbreaks of diseases. Aquaculture is a new activity in Sri Lanka, and the importance of understanding fish health and diseases seems not to have been realized. At present, disease control measures are minimal and it is most unfortunate that none of the fisheries development plans lay any emphasis on disease prevention and fish health. The current status of fish diseases in Sri Lanka is reviewed by Balasuriya (1986).

The proposed and ongoing aquaculture and fisheries development programs seems likely to introduce new species of fishes to the island. So far 17 sqecies of food fishes have been introduced into Sri Lanka (Chandrasoma 1983). According to De Silva (1984), suggestions have been made to introduce African clupeids (*Limnothrissa* species and *Stolothrissa* species) to Sri Lanka. Tippets-Abbot-McCarthy-Stratton (1980) suggested that introduction of *Tilapia sparrmani* A. Smith and *Sarotherodon galilaeus* (L.) would be desirable. To the author's knowledge, no serious quarantine or disease screening measures have so far been taken prior to the introduction of these exotic fishes.

Fernando and Furtado (1963) reported that the occurrence of the cestode *Bothriocephalus gowkongensis* Yeh, 1955 (syn. of *B. acheilognathi* Yamaguti, 1934) in indigenous fish in Sri Lanka was probably a result of importing grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes), from China. This parasite is considered highly pathogenic to young carp and is a serious problem in carp culture in Europe (C. Sommerville, Univ. of Stirling, pers. comm.). Later, Balasuriya (1983) stated that the highly host specific crustacean parasite *Synergasilus major* (Markevich, 1940), which severely affects the gills of grass carp was detected in 1976, just one year after the introduction of grass carp to Sri Lanka. It is also suspected that the crustacean parasite *Lernaea* was introduced into Sri Lanka with exotic fishes. The consequences of the introduction of new diseases to local waters is still to be investigated.

This importation of exotic species of fishes for culture is exclusively carried out and supervised by the government sector. In addition, records indicate that there is a monthly transaction of about 50,000 ornamental fishes belonging to some 300 species for both import and export. The transportation of ornamental fishes is exclusively carried out by the private sector and no restrictions or quarantine are being implemented by the government. This route of introduction of fish diseases is generally neglected, as the ornamental fish trade is of little significance to aquaculture. However, it may play an important role in the international spread of fish pathogens. Therefore, it is important that an organized fish quarantine program be incorporated for the ornamental fish trade.

Live fish trantport within the country is presently handled by the government fisheries stations. There is continuousuransfer of post-larvae, fry, and fingerlings from one station to another. With the recent reorganization of the fisheries stations in the country, on average, approximately eight million cyprinid post-larvae, fry, and fingerlings are being transported between the stations each year. So far, no quarantine measures appear to take place prior to such transportations. Evidence suggests that these fish movements have caused disease outbreaks in various parts of the country (Balasuriya 1983).

A recent survey sponsored by FAO and the Overseas Development Administration (ODA) of the United Kingdom has found that epizootic ulcerative syndrome, possibly caused by a virulent rhabdovirus, is causing severe epizootics in cultured and wild freshwater fishes in certain Southeast Asian countries (see Anon 1986b). So far this has not been diagnosed in Sri Lanka. It is, therefore, very important that preventive legislation, including quarantine measures, be implemented as quickly as possible to prevent its introduction.

As with many other countries in the region (see Davy and Chouinard 1983), there is so far no legislation governing the export, import, and quarantine of fishes in Sri Lanka. The present practice advocated by the Ministry of Animal Production and Health requires that the importer have a satisfactory health certificate from the country of origin certifying that the fish are free of diseases. The consignment of fish is then released immediately. There are no holding or disease screening procedures for imported fishes being undertaken at present. In this context, it is important to raise the question "How is the health certification being carried out?" Health certificates should ideally be issued by qualified, trained, personnel after thorough examination of a statistically valid sample of fish from each consignment. It is also important to standardize the administrative and inspection procedures leading to certification. This level of standardization is already being undertaken by most of the western countries. Canada for example, follows the Fish Health Protection Regulations produced under the Fisheries Act of Canada (Department of Fisheries and Oceans 1984).

Davy and Chouinard (1983) recommended some specific measures which each country in Southeast Asia could implement as part of a system of fish quarantine. Later, the Institute of Aquaculture, University of Stirling, was commissioned by FAO/UNDP to prepare a proposal for a quarantine system and a five year implementation program for Indonesia (see Anon 1984). Much of the information in these reports is relevant and indeed directly applicable to Sri Lanka. However, so far no such measures have been taken by the Sri Lankan government, perhaps due to a lack of trained personnel and expertise.

Two recent developments may change this situation. IDRC, in conjunction with the Sri Lankan government, recently sponsored for training a fish pathologist. In July 1985, the Office International Des Epizooties (OIE) sponsored a regional conference in Colombo. Among other topics, the conference discussed the importance of fish quarantine to Sri Lanka. Officers from the National Aquatic Resources Agency (NARA), the Department of Fisheries, and the Ministry of Animal Production and Health were among the participants from Sri Lanka. These developments can be considered as significant steps towards developing a constructive fish disease screening and quarantine program for Sri Lanka.

Stressing the importance of preventing fish diseases, it must be emphasized that the introduction and movement of fishes should be subjected to strict quarantine measures. This calls for establishment of a fish quarantine unit, supported by legislation that would ensure that appropriate procedures be compulsorily adopted in the import and export of live fishes and their transport within the country.

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FISH QUARANTINE AND CERTIFICATION IN THAILAND

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Quarantine and the certification of fish stocks or shipments as a means of preventing the spread of fish pathogens is becoming very important to ASEAN countries. Thailand, a member country, urgently needs to develop its quarantine system, as due to the success of intensive fish culture, fish disease problems are increasing. Besides the general problem of controlling disease, major disease outbreaks occurred during the years 1981-1985, causing severe economic losses. The exact cause of these outbreaks has not been determined, although many speculative causes have been proposed. Disease transmission through the international fish trade has been considered a possible source of origin.

Thailand's live-fish trade extends to Africa, Asia, Australia, Europe, and North America (Anon. 1980-1987). Statistical records of the Department of Fisheries show that during the period 1978-1985 Thailand exported live food and ornamental fishes to 38 countries and imported fishes from 25 countries (Appendix I). This international trade in live fishes may be an important means of disease transmission if not properly controlled.

Cases of severe outbreaks of epizootic ulcerative syndrome in Thailand and in neighbouring countries (e.g., Laos, Burma, Malaysia) (see Tonguthai 1985) may have resulted from disease transmission between countries, as symptoms shown by infected fishes were very similar. Intensive fish culture as practiced in Thailand could also lead to increased disease problems, as transporting fish from place to place enhances the likelihood of diseases being disseminated. As a result of the recent disease outbreaks and the present disease problems in pond culture, officials of the Department of Fisheries realize that a system of fish health certification and quarantine must be implemented to prevent disease transmission, not only within Thailand, but also internationally.

Current quarantine and fish health certification practices

The study of fish diseases in Thailand has been pursued since 1968, with emphasis on the identification of pathogens and disease prophylaxis and treatment. However, a quarantine system has not yet been developed. At present, the movement of live fish within the country is not regulated. In some cases, disease transmission was obvious, as when fry were transferred from nursery to grow-out ponds and external parasites infecting them were observed. Fish farmers are unable to examine fish and identify diseases because of their limited facilities and knowledge. Consequently, pathogens can be transferred to ponds without notice. Currently, farmers do not employ quarantine methods prior to releasing fish into ponds.

The Department of Fisheries is formulating better diagnostic services for fish farmers, not only in the laboratory but also by providing trained extension personnel in the field. These services will enable farmers to practice disease control in their ponds, especially during the initial stages of infection. Diseases are difficult to control in later stages and delay may lead to severe epizootics.

Fish health certification for the live fish trade is a most effective means of controlling international transmission of disease. As live fish export is a major source of national income in Thailand, the Department of Fisheries has taken responsibility for issuing fish health certificates for exporters. Presently, most countries that import live fish from Thailand require health certificates to accompany shipments. The need for fish health inspection for fish imported into Thailand was also recognized, but presently there is no law or regulation requiring importers to obtain certificates of health.

International trade in live fish

Exportation:

Thailand exports live food and ornamental fishes to some 36 countries (see Appendix I); quantities and values are shown in Appendix II. According to the Fisheries Statistic Record for the period 1978-1985, the quantity of exported food fish has decreased due to a decreased supply of live fish caused by severe disease outbreaks. In comparison, the amount of ornamental fish exported has gradually increased since 1978. At the same time, the number of fish health certificates requested by exporters for these shipments has also increased.

Thailand permits live fish to be exported freely. If a certificate of health is required by the importing country, the exporter must apply to the Department of Fisheries. To obtain the certificate, the exporter must bring at least two fish of each species from each lot to the DoF laboratory for inspection. If the fish are free of external parasites, the certificate is issued; if external parasites are found, suitable treatment is recommended and a reexamination is performed in three to five days. A sample health certificate is shown in Appendix III.

Importation:

The Fisheries Statistic Record shows that the amount of imported live food fish has dropped dramatically since 1979 when a total of 344 tons valued at 14,305,000 Baht were imported. Importations had declined to only a single ton valued at 833,000 Baht by 1983 and have continued to be extremely low, with only two and three tons of live food fish being imported in 1984 and 1985, respectively (see Appendix II). The successful development of aquaculture in Thailand may have caused this decrease.

Thailand still acquires many species of ornamental fishes abroad. During the period 1978 to 1983 these imports rose from 11 tons valued at 992,000 Baht to 14 tons valued at 9,431,000 Baht, with a corresponding increase in the number of exporting counties from 8 to 30. However, since 1983 the quantity of ornamental fishes imported has declined to only four tons with a value of 3,046,000 Baht in 1985.

To import live fishes into Thailand, the importer must obtain a permit from DoF. There are some species, such as Chinese carp and piranha, which are not allowed to enter the country (see Appendix IV). Restricted species, if found at the port of entry by DoF personnel, will be confiscated and destroyed. At the present time, neither a disease examination nor a health certificate is required for imported fish.

Weaknesses and limitations of the current system

The procedure for obtaining a fish health certificate from the Department of Fisheries is very simple. The certification process, however, has several weaknesses.

1. *No statistical basis for sampling is used.* As the DoF requires a minimum of two fish of each exported species for inspection, the exporter will normally bring only this number, which is an inadequate sample size for disease detection.

2. *No standard sampling method is employed.* Fish samples are taken by the exporter, who may not conduct the sampling properly. Presently, the DoF inspector has no control over sampling methods.

3. *Inadequate inspections for pathogenic organisms are made.* Fish samples are inspected only for external parasites. Internal parasites, bacteria, and viruses are not included.

In addition to these three weaknesses in the inspection process, there are limitations to effective disease diagnosis.

1. *Limited diagnostic expertise.* DoF has three laboratories, the National Inland Fisheries Institute (NIFI), the Brackishwater Division, and the National Institute of Coastal Aquaculture (NICA) which share responsibility for diagnostic services and the issuing of fish health certificates. Of these, NIFI is best equipped for this purpose. However, NIFI's expertise is limited to the study of parasites and bacteria; very little work on viral and fungal diseases is presently conducted.

2. *Limited facilities.* To issue health certificates for live fish, it is necessary to identify pathogenic organisms rapidly. This requires advanced technology and facilities.

3. *Limited staff.* Presently, export of live fish is increasing. Not only fish are exported, but also shrimps and other aquatic animals. Therefore, the demand on health inspection personnel is increasing.

Strengthening quarantine control

The Department of Fisheries has realized the importance of quarantine control as a result of the severe disease outbreaks which have occurred. It is now generally agreed that an effective quarantine system must be developed. To accomplish this, the DoF has established two working committees to implement a quarantine system. The first working committee is to prepare and develop a fisheries law and legislation on quarantine control and certification. The second committee is charged with developing an effective quarantine system and improving certification procedures.

The DoF is making a great effort to equip its laboratories with the necessary scientific equipment for rapid disease diagnosis and to increase both the number of fish health workers and their expertise. Additional staff are being trained in Thailand and abroad in proper and advanced diagnostic methods.

Inspection offices at international airports must have adequate equipment. There is now an office at Donmuang (Bangkok) Airport. As Thailand has three international airports, each must have adequate facilities to inspect imported/ exported fish and aquatic animals for both disease and restricted species.

The International Development Research Centre (IDRC) is one of the donor agencies which realizes the importance of fish disease control and assists countries in Southeast Asia in improving their quarantine systems. Thailand currently receives support from IDRC which will improve capabilities on viral diseases. Research on methods to control fish diseases will also be conducted.

In addition, it would be useful for ASEAN countries to establish a regional committee on fish quarantine and certification. This committee would be charged with developing and recommending uniform methods for the holding and inspection of fish shipments and rearing facilities, maintaining a list of pathogens of concern, and advising member countries of current disease problems in Southeast Asia.

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Appendix I
List of countries involved in the trade of live fishes with Thailand

Countries Importing Fishes From Thailand	Countries Exporting Fishes To Thailand
Australia	Australia
Belgium	Belgium
Brunei	Brazil
Canada	Burma
Denmark	Canada
Federal Republic of Germany	Denmark
Finland	Federal Republic of Germany
France	France
Greece	Greece
Hong Kong	Hong Kong
India	Indonesia
Indonesia	Iraq
Iraq	Israel
Israel	Italy
Italy	Japan
Japan	Malaysia
Jordan	Netherlands
Kuwait	People's Republic of China
Malaysia	Philippines
Netherlands	Singapore
New Zealand	Sri Lanka
Norway	Sweden
Philippines	Taiwan
Poland	United Kingdom
Portugal	U.S.A.
Republic of Korea	
Rhodesia	
Saudi Arabia	
Singapore	
South Africa	
Sri Lanka	
Southwest Africa	
Sweden	
Switzerland	
Taiwan	
United Kingdom	
U.S.A.	
U.S.S.R.	

Appendix II
Quantity and value of exported and imported live food and ornamental fishes for the period 1979-1985

	Exported				Imported			
Year	Food Fishes		Ornamental Fishes		Food Fishes		Ornamental Fishes	
	Quantity[1]	Value[2]	Quantity	Value	Quantity	Value	Quantity	Value
1978	556	23,164	151	12,052	253	22,537	11	992
1979	313	6,399	147	11,782	344	14,305	1	432
1980	455	25,064	166	14,047	53	9,254	9	1,831
1981	430	30,900	152	14,839	51	5,505	8	4,186
1982	296	26,717	179	16,733	9	12,416	13	9,054
1983	124	13,454	165	15,563	1	833	14	9,431
1984	75	6,606	266	24,571	2	660	8	6,982
1985	155	11,774	306	29,200	3	2,036	4	3,046

[1]Metric tons.
[2]1000 Baht.

Appendix III

No. AG 0511/

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Health Certificate

The sample of live fish species (3 species) from Suthep Aquarium were inspected at NIFI, Bangkhen, Bangkok 10900, on April 18, 1986. At the date of inspection, the fish were seen to be healthy and clinically free from infectious or contagious disease.

Gyrinocheilus aymonieri
Balantiocheilos melanopterus
Rasbora heteromorpha

Dr. Thiraphan Bhukaswan
Director, NIFI

Miss Sopa Areerat
Fish Pathologist

NIFI
Tel. 5792151, 5790562,5792619

Date ..../........./.......

Appendix IV
Restricted fish species for importing to Thailand

Common name	Scientific name
Bighead carp	*Aristichthys nobilis* (Richardson)
Common carp	*Cyprinus carpio* (L.)
Grass carp	*Ctenopharyngodon idella* (Cuvier and Valenciennes)
Silver carp	*Hypophthalmichthys molitrix* (Cuvier and Valenciennes)
Piranha	*Serrasalmus nattereri* Kner
Piranha	*Serrasalmus niger* (Schombusgk)
Piranha	*Serrasalmus serrulatus* (Valenciennes)
Piranha	*Pygopristis denticulatus* (Cuvier)
Piranha	*Serrasalmus rhombeus* (L.)
Piranha	*Serrasalmus spilopleura* Kner

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THE ASIAN FISHERIES SOCIETY

The Asian Fisheries Society seeks to promote interaction and cooperation among Asian fisheries scientists and technicians; to propagate an awareness of the importance and the ways of sound conservation and use of aquatic resources; and to join in these goals with similar societies. The Society consists of over 1,000 scientists (full members), primarily from Asia, as well as many persons (associates) and organizations (institutional and sustaining members) interested in Society's objectives. If you would like more information or wish to join the Society, please contact the Secretary, Asian Fisheries Society, MC PO Box 1501, Makati, Metro Manila, Philippines. Membership fee is $10. There are no annual dues.

CANADA

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America and the Middle East.